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CASE STUDY: A REPORT ON THE STORM SYSTEM OF 2 MARCH 1977.(U)

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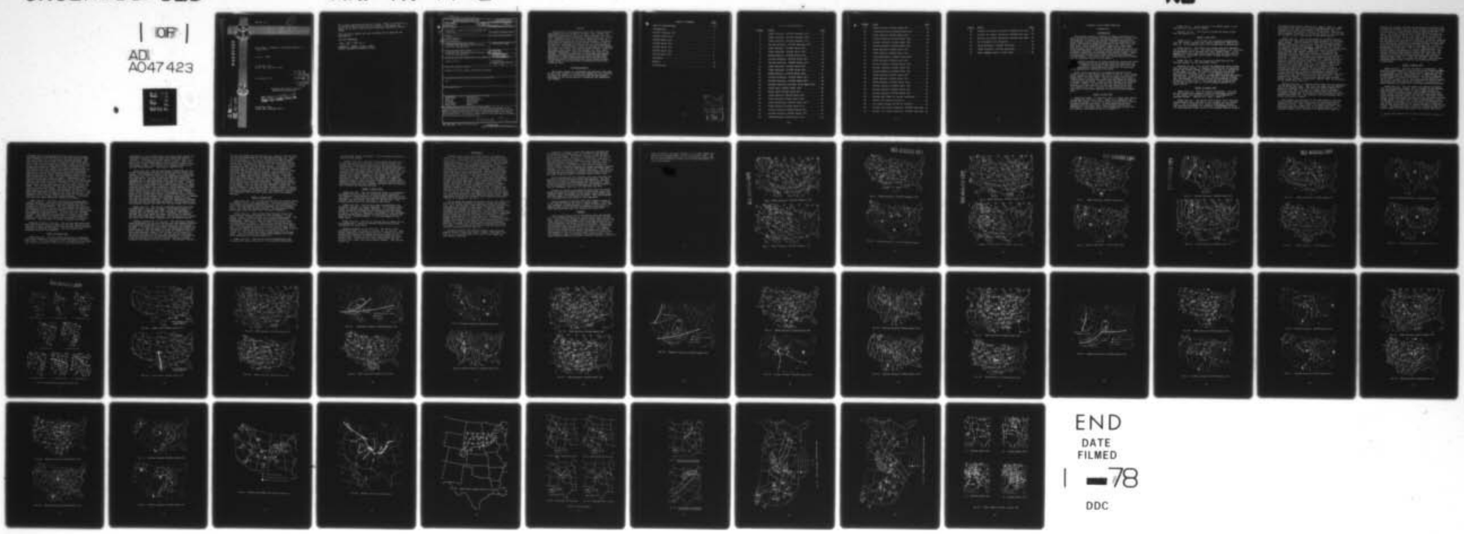

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# Case Study: A Report on the Storm System of 2 March 1977

Eugene M. Weber

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15 November 1977



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| 300mb Jet | Main Surface Low |
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| Height Falls | Midwest |

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This Technical Note uses the storm of 2 March 1977 as verification for the empirical and subjective rules described in 3WW Technical Note 76-1, Low Level Moisture Advection and 3WW TN 76-2, Major Snowstorm Development Over the Midwest United States. The sudden northward shift of this storm was in accordance with the rules previously presented.

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## PREFACE

Third Weather Wing Technical Note 76-2, Major Snowstorm Development over the Midwest, December 1976, offered the reader various surface and upper level features that have been associated with significant snowfalls over the central U.S. Included within TN 76-2 were subjective rules for identifying and steering developing snowstorms. Snowstorm data from the subsequent winter season (1976-1977) was to be used for continued verification of the rules presented in TN 76-2. Unfortunately, there was minimum storm development over the central and southern plain states. A prevailing upper level ridge over the western U.S. until late February maintained a cold, dry airflow over much of the midwest. Conditions favorable for snowstorm development increased in late February and continued through March. Nearly all of these storm systems were associated with developing and/or intensifying long wave trough systems. A case study of one such storm is presented within this Technical Note.

## ACKNOWLEDGEMENTS

The author wishes to acknowledge the skillful work done by Mrs Diana LeBoeuf in typing and assembling, the plotting of upper air charts by AlC Troastle and the painstaking work done by AlC David Nelson in enhancing and assembling the figures.

TABLE OF CONTENTS

## List of Illustrations

# A REPORT ON THE STORM SYSTEM OF

# 2 MARCH 1977

## INTRODUCTION

This report contains a summary of events pertaining to a storm system that affected the central Midwest on 2 March 1977. The majority of central and eastern Nebraska received rain while western and northern Nebraska received significant snowfalls. The heaviest snowfall occurred to the left of a line from North Platte, Nebraska (LBF) to Sioux City, Iowa (SUX). Both the National Weather Service (NWS) and the Air Force Global Weather Central (AFGWC) prognoses predicted snow for all of eastern Nebraska. This storm system turned abruptly northeastward towards central Nebraska from western Kansas. Upper air progs had forecast this storm system to move eastward through Kansas. The reasons why this system shifted northward will be discussed later in this report.

An orderly discussion of events preceding, during and after rm development will be presented using the subjective and irical guidance contained in 3WW Technical Notes 76-1 and 2. Reference to these Technical Notes will be indicated (when appropriate) throughout the report.

Each 12 hour period will be presented beginning with 1200Z, 28 Feb 77 and ending with 1200Z, 3 Mar 77. This system moved toward the West Coast from the northern Pacific-Gulf of Alaska area as a short wave. Upper air changes occurred on 2 March which indicated the short wave had become an apparent long wave trough system. Some of these changes were detected at 1315Z, 2 March. It was decided that the upper air was changing over the western U.S. and that Offutt would have rain rather than snow. The NWS and GWC forecasts at that time were for snow over Nebraska including the Offutt/Omaha area.

## 1200Z, 28 Feb 1977

300mb and 500mb. In Figures 1 and 2, a short wave trough is approaching the West Coast. There is no organized low within the trough. A jet stream with a 90 knot max is moving southeast behind the trough. A 500mb height falls area appears along the West Coast from northern California to Washington. The height falls center apparently is just off the coast as indicated by the X in Figure 2.

850mb (Fig 3). A low appears at the 850mb level in conjunction with the surface system.

Surface (Fig 4). A mP frontal system has moved inland over the western U.S.

<u>0000Z, 1 Mar 1977</u>

300mb (Fig 5). A 80-90 knot jet continues southeastward into the trough's bottom over central California (3WW TN 76-2, page 1). A low appears within the trough west of Washington.

500mb (Fig 6). The short wave trough continues eastward and is moving at 25 kts. The height falls center (-15) continues southeastward and is located near Reno, Nevada (RNO). A low appears within the wide contour spacing just off the coast of Washington. The height falls center is some distance to the south of the low.

850mb (Fig 7). The low is moving inland and now has vertical support at the 500/300mb levels.

Surface (Fig 8). The low off the Washington coast stacks with the upper system. It appears that this low is remaining behind the frontal system (lingering low) and is a reflection of the upper air low. The frontal system over the Nevada-Utah area is beginning to wave. A low appears along the frontal wave. A small high is located over northern New Mexico. The cold air source preceding this system is the cP airmass over the Midwest. All these features are presented on pages 34 and 36 of 3WW TN 76-2. The lingering low in Washington has filled and has lost its closed isobaric feature by 01/0600Z (Fig 9).

<u>1200Z, 01 March 1977</u>

300mb (Fig 10). Good jet support continues. A 90 knot jet max isotach area appears within the southeast quadrant of the trough over southern California northeastward to southern Nevada. (3WW TN 76-2, page 1, para 2)

500mb (Fig 11). The height falls center (-17) continues southeastward and is located in the vicinity of Ely, Nevada (ELY). The low appears over central Washington; however, the area most favorable for eventual low placement would be over northeastern Nevada north of the tighter contour gradient

and height falls center (3WW TN 76-2, page 6, para 1). Note that the height falls area extends southwestward into lower California (-11 over Los Angeles) indicating the hint of another short wave impulse possible in the flow. This height falls pattern is similar to the pattern shown in Fig 17b, page 23, of 3WW TN 76-2, which became a long wave feature.

850mb (Fig 12). The low has moved to southwest Montana reflecting the continued southeastward movement of the entire upper system. The low appears to have moved rapidly southeastward within the last 12 hours from its previous position off the west coast of Washington. Apparently, the old low dissipated over central Washington while a new low formed within the deepening 850mb trough. Some weak wind circulation is still evident over central Washington. This system has developed from the 850mb level and above; therefore, the 850mb low should be considered as the main low for steering purposes. A number of surface lows appeared along the mP front as it moved across the western U.S. Identification of the main surface low would have been an easier task if the 850mb low were followed (Fig 45). It states in 3WW TN 76-2, page 30, that developed upper lows that moved inland from the Pacific and/or Gulf of Alaska, as a general rule, already have vertical support to the surface; therefore, an associated 850mb low should be considered as the main low. If the upper system is moving southeasterly towards the southern Plains (bottoming out) the associated 850mb low will likely move into the lee-side trough and intensify. (This sequence did happen.) Gulf moisture appears over eastern Mexico in the vicinity of Monterrey, Mexico (MTY) as indicated on the 850mb chart (Fig 12).

Surface (Fig 13). A lagging frontal wave with an associated low has moved into Utah. Note that the 850mb low and surface low do not ideally stack. The cold air source (3WW TN 76-2, page 32) continues to be the cP airmass over the Midwest. At 01/18Z (Fig 14), a second low appears along the front in northwest Colorado and is probably a surface reflection of the approaching 850mb low. The lingering low over eastern Washington continues to weaken.

Let's shift our attention to the time period of the low level moisture advection which fed into this storm system (Figures 15a-15h). Gulf stratus was initially observed in Texas over Del Rio, Texas (DRT) at 01/1400Z (Fig 15a). The moisture advected northwestward from eastern Mexico into southwest Texas (type 1 advection in 3WW TN 76-1, page 10).

Figures 15a through 15h show the progression of stratus into the central Midwest. The low level jet was evident by 0000Z, 2 March (Fig 17) over western Texas to western Nebraska, and the relationship between stratus advection and the jet is ideal. As noted in 3WW TN 76-1, pages 18-19, the NWS does not scallop ceilings above 3,000 feet. This is obvious in Figures 15b to 15h. In Fig 15a, both MTY (in Mexico) and DRT are scalloped, but are not connected. There is, although not depicted on the analysis, an identifiable tongue of moisture from eastern Mexico to southwestern Texas as indicated by the hatched area in Figures 15a through 15d. It was mentioned in 3WW TN 76-1, page 6, that Gulf stratus is considered below 5,000 feet. It is also interesting to note how the tongue was depicted on charts after Fig 15d. The stratus ceilings were observed below 3,000 feet after Fig 15d due to cooling and higher elevations. The tongue is quite evident in Fig 15e. Note the scalloped area over Lubbock, Texas (LBB) in Figures 15b and 15c. The area was scalloped because the visibility was restricted due to blowing dust.

0000Z, 2 March 1977

300mb (Fig 18). The jet continues to strengthen. One important consideration at this point in the future movement of the system is that the maximum isotach area has shifted southwestward from 12 hours previously. Additionally, the maximum wind area has strengthened to 110 knots (although it is located in an area of no data). It was mentioned in 3WW TN 76-2, pages 3 and 4, that maximum wind area(s) appearing within the south-southwest quadrant of a trough will cause problems in steering of the system located downstream.

500mb (Fig 19). The low center has shifted southeastward to northeastern Nevada, and is located in the forecast area mentioned in the 1200Z, 01 March 500mb discussion. There is one disturbing factor that appears on this chart which, along with the maximum isotach area mentioned above, could produce changes within this trough. The height falls center (-12+)[1] has dropped southward to the California-Arizona border rather than taking the normal southeasterly course. In 3WW TN 76-2, pages 3, 20, 24 and 58 it is suggested that when height falls centers move southward and/or southwestward of the associated low it causes problems in steering the system. Increasing evidence (based on 3 storm systems this month) shows that when the height falls center does shift

1. The plus sign indicates that the height falls center is between -12 and -13.

southward and/or southwestward within a short wave trough, the subsequent 500mb analyses will indicate that the short wave is changing into an apparent long wave pattern. The low center will then become a minor short wave which will move up the long wave trough as shown on page 10 of 3WW TN 76-2. This is the primary reason which indicated that this system was undergoing changes, and that at 02/1315Z the forecast was that any precip over eastern Nebraska would be rain rather than snow because the associated low system, in addition to the height falls center would move northeastward across central and/or western Nebraska rather than eastern Nebraska and Iowa. The associated surface low would then track northeast, west of Omaha. Consequently, any snowfall would fall along and west of either the surface low track or the 500mb low track depending on how cold the storm was (See 3WW TN 76-2 page 51). In Fig 19, note that a -12 height falls center was reported over San Diego, California (SAN). This is definitely a clue that further digging is occurring within the trough. As mentioned earlier, this upper system and its height falls movement is similar to the case study presented on pages 23 and 24 of 3WW TN 76-2. The composite chart (Fig 20) depicts the 300mb jet stream relationship with the height falls center movement. It can be seen that the upper trough was undergoing changes.

850mb (Fig 21). The main low continues southeastward towards Colorado. This low is well-organized and should be followed in determining where the main surface low will organize lee of the Rockies. Note the surface low positions in Figures 22 and 23. In Fig 22, the surface low appears in the vicinity of the 850mb low; however, in Fig 23, two surface lows appeared along the front. In this case, the Colorado low should be considered as the main low since it has 850mb support (See page 30 of 3WW TN 76-2). A strong pressure gradient exists over the Plains which produced a strong low level jet. Gulf moisture is moving northward from Texas.

Surface (Figures 22 and 23). The cP high has moved eastward resulting in warm air advecting over the central Plains. Cold air is still prevailing over the Rockies and the western sections of Nebraska and Kansas. Snow is falling over scattered areas of the Rockies.

<u>1200Z, 02 March 1977</u>

300mb (Fig 24). The jet stream continues to strengthen with a wind maximum of 130 knots shown over Mexico and southwest Texas. The wind maximum is still located south and southwest of the low system. Normally, at this stage of low

development, a wind maximum would have been shown within the southeast quadrant of the trough over Kansas and eastern Colorado. A definite clue does appear in Fig 24 that a new short wave has developed behind the low system. Note the short wave trough from Nevada across central California into the Pacific Ocean. This trough is not readily seen on the related 500mb analysis. (See page 3, 3WW TN 76-2.)

500mb (Fig 25). The low system has slowed down but continues southeastward towards its lowest position within the trough. The associated height falls center (-12+) has moved ENE within the last 12 hours and has apparently bottomed out over New Mexico. Another indication that the system has bottomed out is that the height falls center's central value remained nearly unchanged during the last 12 hours (Page 8, 3WW TN 76-2). It was mentioned in 3WW TN 76-2, page 10, that short wave troughs within a long wave trough move in a nearly straight line towards the northeast in the direction of flow after bottoming out. This particular system is becoming a short wave within a long wave trough at this time; however, it hasn't quite reached that stage of development yet. Consequently, the height falls center track did not follow a northeast course, but continued in an easterly direction. It appears now that the system should turn northeast towards eastern Colorado and western Nebraska. Good cold advection is feeding into the low over Arizona and New Mexico. Fig 26 depicts the relationship between the 300mb jet and the height falls center.

850mb (Fig 27). The low has noticeably slowed down over Colorado during the past 12 hours. The primary reason for slowing down is because the 500mb low was not previously stacked with the 850/surface low. Therefore, the 850mb low "waited" until the upper low caught up and now is stacked. The low has become well-organized. Gulf moisture and a strong low level jet (>50 knots) appeared over the central plains.

Surface (Figures 28, 29, and 30). The following sequence shows development of the main surface low over eastern Colorado and subsequent dissipation of the existing low over western Colorado. In Figure 28, the western Colorado low has been the primary low and was associated with the approaching 850mb low. Note, however, that the 850mb low shown in Figure 27 has now moved southeastward ahead of the surface low in Figure 28. The ideal stacking of these two lows has now been disrupted because the surface low is becoming stationary. In Figure 29, a new low appears over eastern Colorado while the western Colorado low remains nearly stationary. The eastern Colorado

low has now become the main surface low (page 34, 3WW TN 76-2) and has developed ahead of the approaching 850mb low. Rapid intensification of this new low should occur when it moves out of the Rockies. The western Colorado low has become a "lingering low" (page 60, 3WW TN 76-2) and eventually should fill as the upper trough passes over it. In Figure 30, the lingering low has lost its closed isobaric circulation and has continued to weaken while the new low has deepened 4 millibars during the past three hours. The actions of these lows over the central and/or southern Rockies during the period of upper level trough deepening west of the Rockies is not uncommon and should be followed closely. The mistake most often made is identifying the lingering low as the main surface low rather than the rapid developing low that often forms lee of the Rocky Mountains. Significant snowfall is occurring over Colorado, Wyoming and western Nebraska and South Dakota. Rain is falling over Oklahoma, Kansas and eastern Nebraska. The NWS and AFGWC surface prognosis charts based on 1200Z, 2 March data finally indicated that the system was moving northeast (bottomed out) and subsequent precipitation forecasts were for rain rather than snow over eastern Nebraska.

## 0000Z, 3 March 1977

300mb (Fig 31). It is quite obvious that the trough system is changing into a long wave pattern. The storm system over the Rockies is moving northeastward out of the developing long wave. The wind maximum area has expanded and still remains within the long wave trough's bottom. The approaching short wave trough from the west coast continues southward.

500mb (Fig 32). The low has moved eastward during the past 12 hours and has bottomed out over Colorado. It has become a small, compact system as it moves northeastward. The height falls center (-19) has moved northeastward from Albuquerque, New Mexico (ABQ) to Dodge City, Kansas (DDC) and intensified 70 meters. Height falls centers generally increase after bottoming out as explained on page 8 of 3WW TN 76-2. The approaching short wave trough from the West Coast that was not easily identifiable on the previous 500mb analysis (Figure 25) has now become more pronounced as shown in Figure 32. The trough has finally worked down to the 500mb level. Figure 33 shows the relationship between the height falls center and the related 300mb jet.

850mb (Fig 34). The low has moved southeastward from Colorado into western Kansas and has deepened considerably.

A major storm system is evident. Gulf moisture continues to feed into the system.

Surface (Fig 35). The low has not moved very far east during the past six hours and a valid reason is that the surface low slowed down in response to the bottoming out action aloft. In the 02/1200Z surface discussion previously, a new low appeared within the lee-side trough at 02/1500Z (Fig 29) which was some distance ahead of the 500mb low. The lingering low discussed earlier has now dissipated (Fig 35) and the only surface support for the upper low is now the system over Kansas. Therefore, the surface low "waited" (see page 56, 3WW TN 76-2) until the upper low caught up. Figures 36 and 37, show the storm system as it moves northeasterly towards central Nebraska. Moderate precipitation is occurring within the storm system; the heavy snow is falling over Colorado and western Nebraska.

## 1200Z, 3 March 1977

300mb (Fig 38). The jet stream has swung to a southwest-northeast orientation due to continued trough deepening. The Nebraska storm appears as a weak trough system within the long wave. A second low has developed within the wide contour gradient over New Mexico (see page 3, 3WW TN 76-2). The maximum isotach area has increased to 150 knots.

500mb (Fig 39). The low has moved northeastward from southeast Colorado to central Nebraska. A -13 height falls center is located over Omaha, Nebraska. The height falls center decreased 60 meters which indicates that the system is dying. An area of suspected cyclogenesis is over southern Arizona and New Mexico within the wide contour gradient and north of the tighter gradient. A low does appear at the 300mb level.

850mb (Fig 40). The low is located west of Omaha and is very pronounced. Excellent thermal discontinuity exists throughout the storm area.

Surface (Figures 41, 42, and 43). The storm's slow northward movement is shown in Figures 41, 42, and 43. This system eventually became stationary for 12 hours over southeastern South Dakota and dumped excessive snowfalls over northeastern Nebraska, southeastern South Dakota and northwestern Iowa. One reason the system slowed down was the presence of a ridge over south-central Canada (See Figures 38 and 39).

## DISCUSSION

Figure 44 is a composite chart showing the 500mb low center, the 500mb height falls center and the main surface low tracks. The height falls center track shows the abrupt shift southward to Arizona during the period when the upper trough was changing into a long wave pattern. This system undoubtedly would have produced a major snowfall over central and eastern Nebraska and northward if it had moved southeast and bottomed out over west Texas. The surface low bottomed out over western Kansas approximately 6 hours after the upper system bottomed out. The heavy snow area lies along and to the left of the 500mb low center track across western Nebraska. The heavy snow lies along and to the left of the surface low track in northeastern Nebraska because the storm was colder in the lower level there than it was in western Nebraska. Also, the storm remained nearly stationary over the southeastern section of South Dakota for some time which helped to produce excessive snowfall amounts. On page 51, 3WW TN 76-2, it states that the heavy snow area will remain to the left of either the surface low or the 500mb low depending on how cold the storm is. In nearly all cases, the heavy snow area will at least lie along and parallel to the 500mb low center track. These subjective rules are for receding high pressure situations (3WW TN 76-2, pages 51, 52, 53).

Fig 45 shows the tracks of surface lows and the 850mb low during the frontal system's progression across the western U.S. As it can be seen, there were many surface frontal lows throughout the history of this storm. Note the reliable southeastward movement of the 850mb low from the Pacific northwest to Colorado (indicated by a solid square in Fig 45). Developed 850mb lows that moved into the West Coast associated with an upper low must be followed for continuity in determining which frontal low is the main low. Although not stated in 3WW TN 76-2, it would be wise to follow 850mb lows rather than surface lows over the mountainous terrain of the western U.S. Much of the 850mb level is at the surface. Note the "lingering low" over central Colorado from 02/12Z to 02/18Z. It is apparent from Fig 45 that the wrong low could be identified as the main low.

Figure 46 depicts the snowfall amounts that occurred between 1200Z, 2 March and 1200Z, 3 March. The heavy snow line ($\geq$ 4") lies along and to the left of the 500mb low over western Nebraska.

Figures 47 through 51 show the comparison between the NWS progs and the AFGWC progs in forecasting the movement of the storm system. The figures are in 12 hour periods beginning with 1200Z, 28 Feb 77. In Figures 47, 48 and 49, both forecast agencies progged the low to move southeastward into Kansas and then eastward across Kansas. Snow was forecast for all of Nebraska. In Fig 49, note that the actual surface low bottomed out over western Kansas and turned towards Nebraska although the progs indicated eastward movement. In Fig 50, the NWS progs caught the change and forecast the low to move into eastern Nebraska. The GWC prog did show an east northeast movement into northern Missouri, but then moved the system southeast towards Saint Louis.

Fig 52 depicts the 540 thickness line prog from the LFM series at the 36 hour and 48 hour time periods. The data base was at 1200Z, 01 March which was during the critical period for issuing snow advisories for the Midwest. Snow would be forecast for all of Nebraska and western Kansas if the 540 thickness line rule for snow/rain was used.

Figures 53 and 54 are composites which show the actual 500mb low center and height falls center tracks versus the forecast 500mb low center and vorticity center tracks from LFM data bases of 01/0000Z and 01/1200Z. The 540 thickness line forecasts are also shown on the composite.

Figure sequence 55 depicts NWS radar summary charts in 6 hour periods during the storm's early stages. A significant increase in precipitation is shown in Figure 55c. The leading edge of Gulf stratus had advected into Kansas by 1600Z and coincides with the increase in Figure 55c.

## SUMMARY

Each trough moving into or developing over the Western U.S. is a potential threat for a major storm over the Midwest. Some of these troughs undergo changes which eventually alter the storm's development and track over the Midwest. In this particular case study, there was evidence early in the period indicating that changes were occurring. Forecasters could detect these changes within the upper air before the new set of centralized progs were available. The sudden shift of the height falls center southward along with the development of the jet max southwest of the low center were two important clues that changes were taking place. This storm system probably would have produced significant snowfalls

over the central and upper Midwest if the ideal 500mb low/ height falls tracks shown in 3WW TN 76-2 were taken. The empirical and subjective rules in 3WW Technical Notes 3WW TN 76-1 and 3WW TN 76-2 worked well during the history of this storm system.

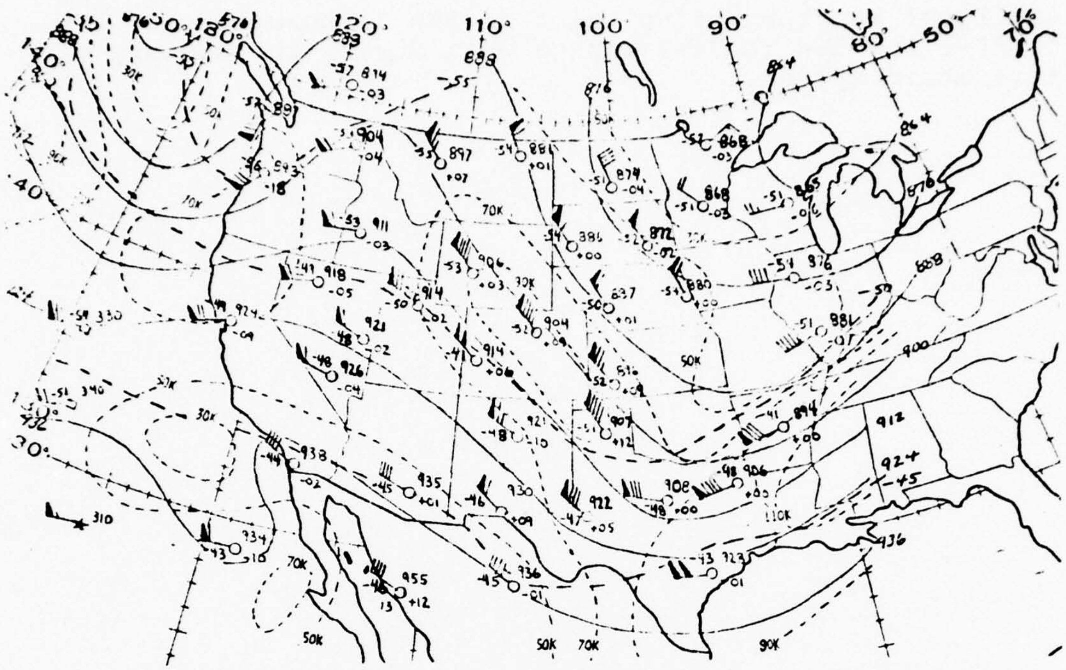



Fig 1. 300mb Analysis, 281200Z February 1977

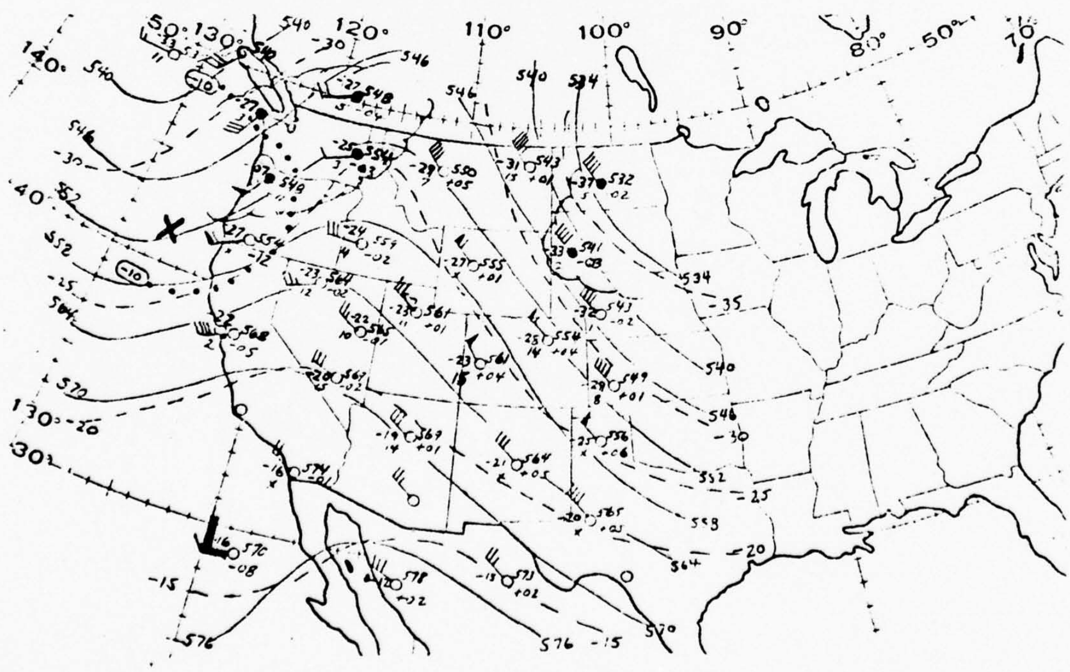



Fig 2. 500mb Analysis, 281200Z February 1977

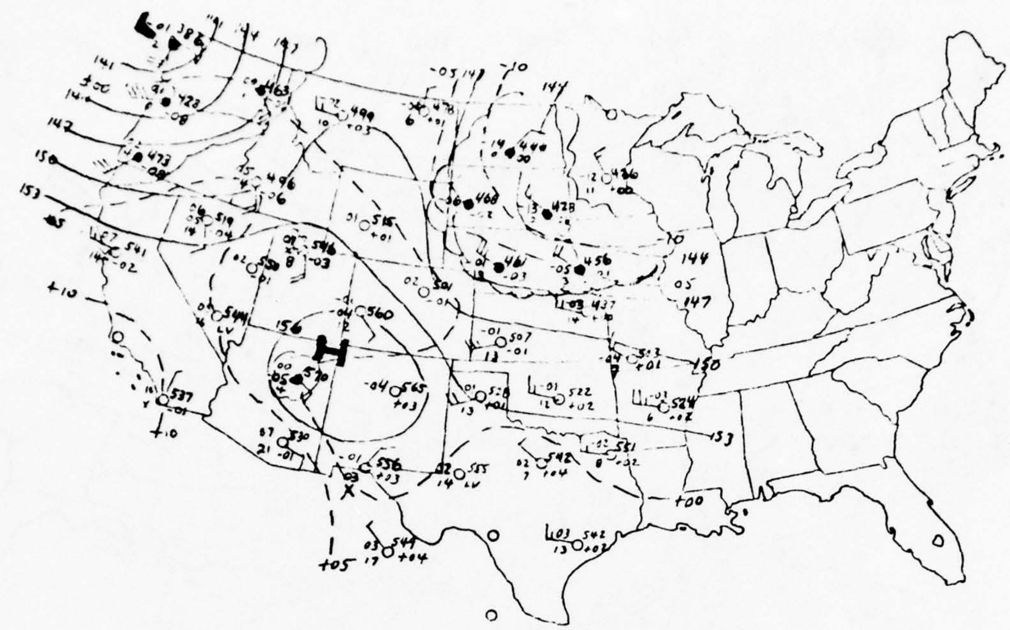



Fig 3.  850mb Analysis, 281200Z February 1977

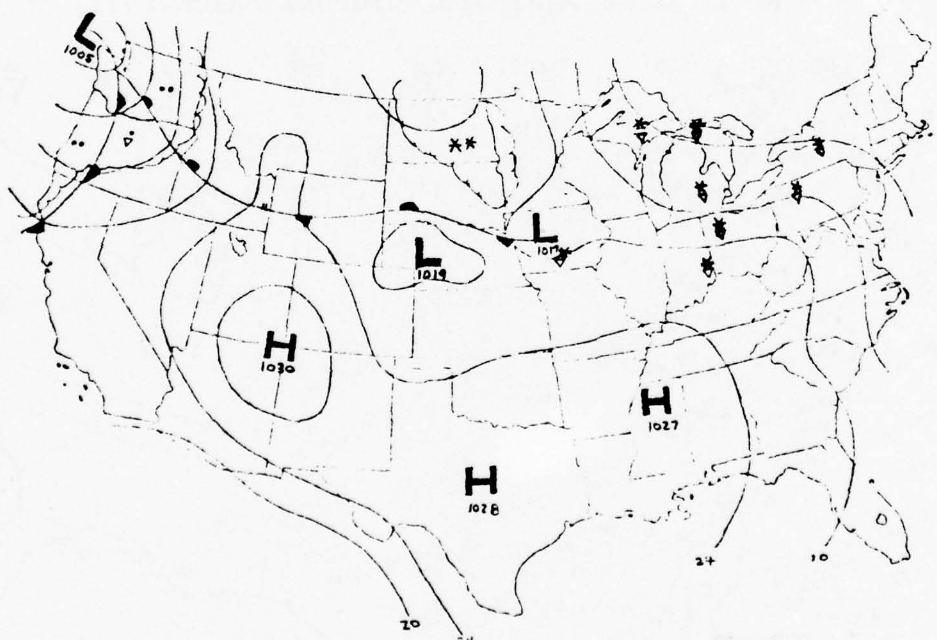



Fig 4.  Surface Analysis, 281200Z February 1977

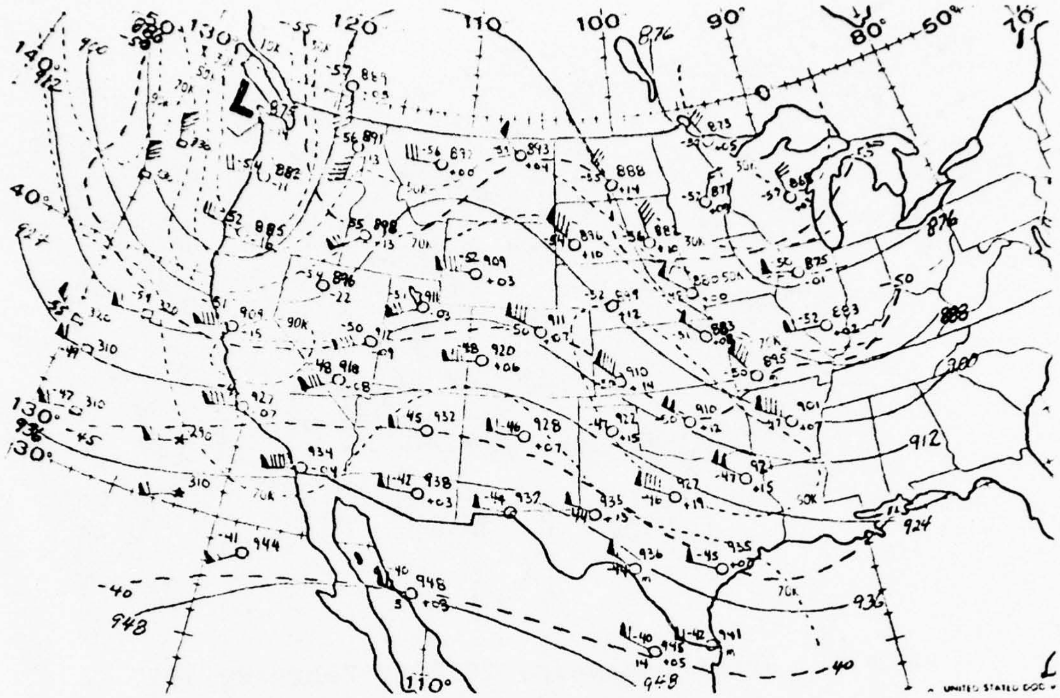



Fig 5. 300mb Analysis, 010000Z March 1977

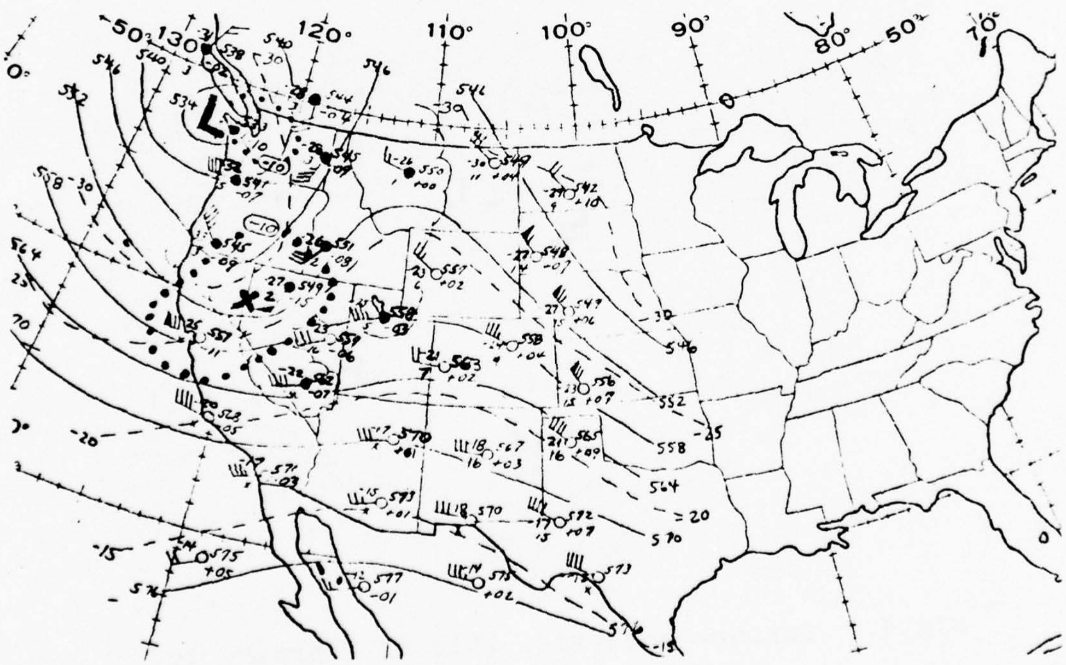



Fig 6. 500mb Analysis, 010000Z March 1977

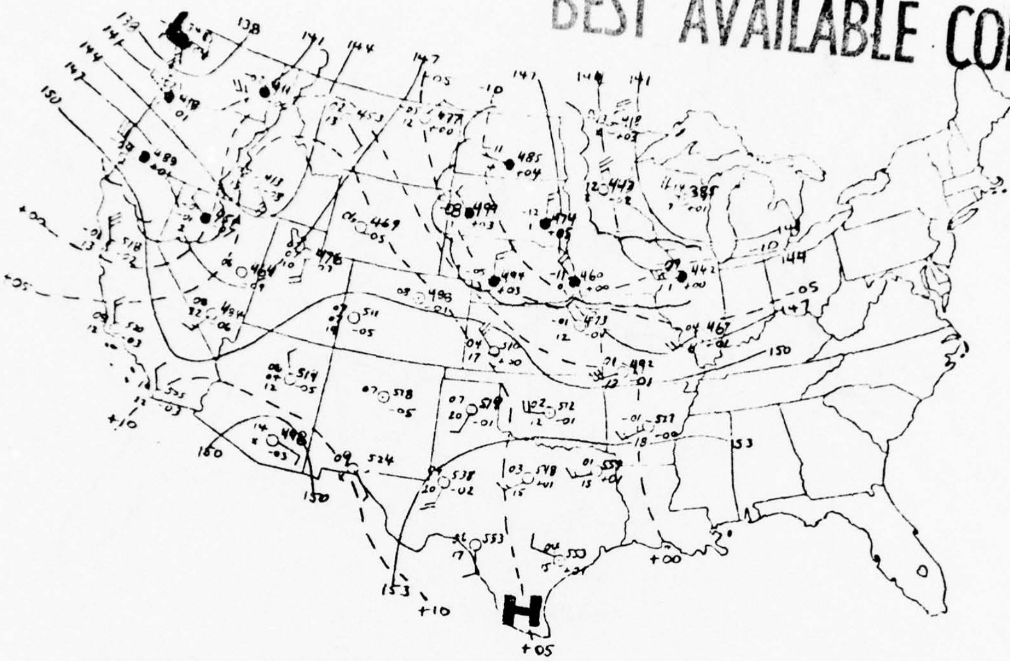


Fig 7.   850mb Analysis, 010000Z March 1977

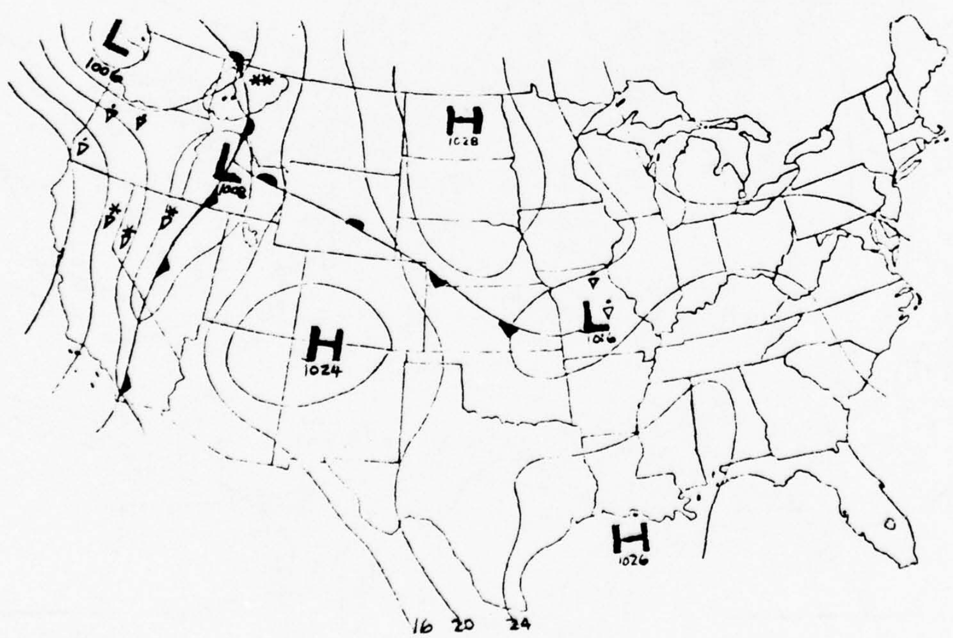



Fig 8.   Surface Analysis, 010000Z March 1977

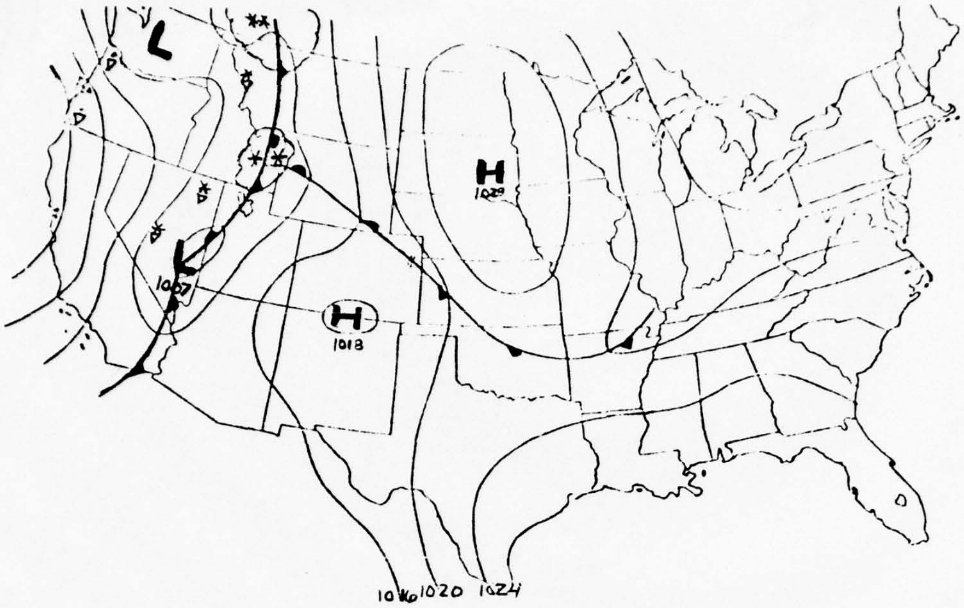



Fig 9. Surface Analysis, 010600Z March 1977

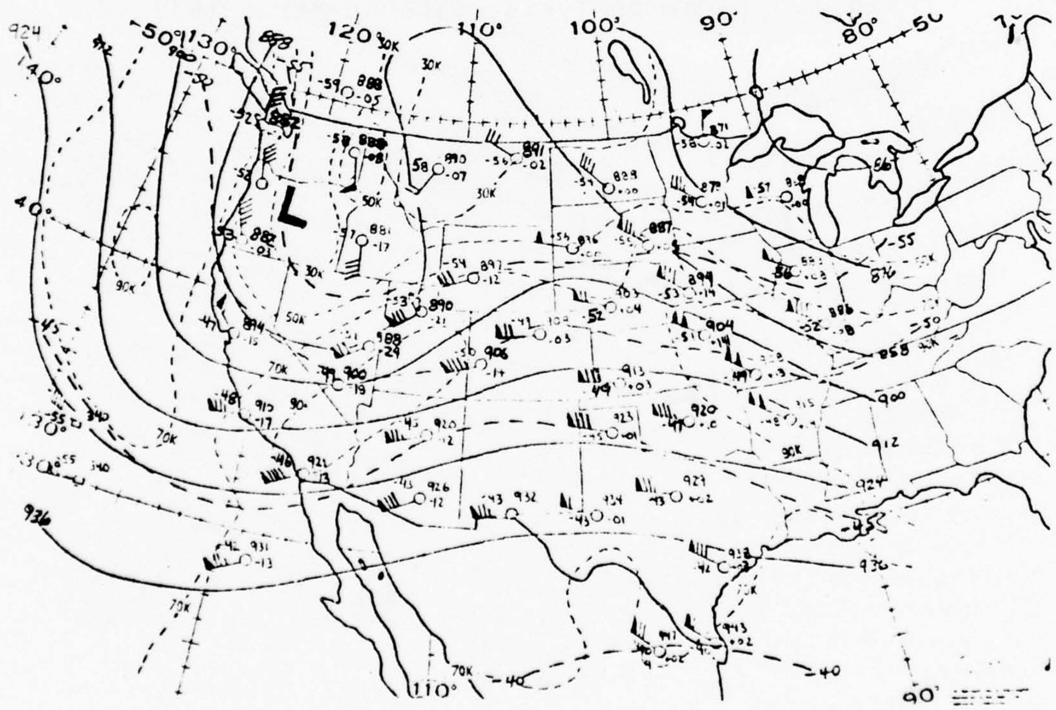



Fig 10. 300mb Analysis, 011200Z March 1977

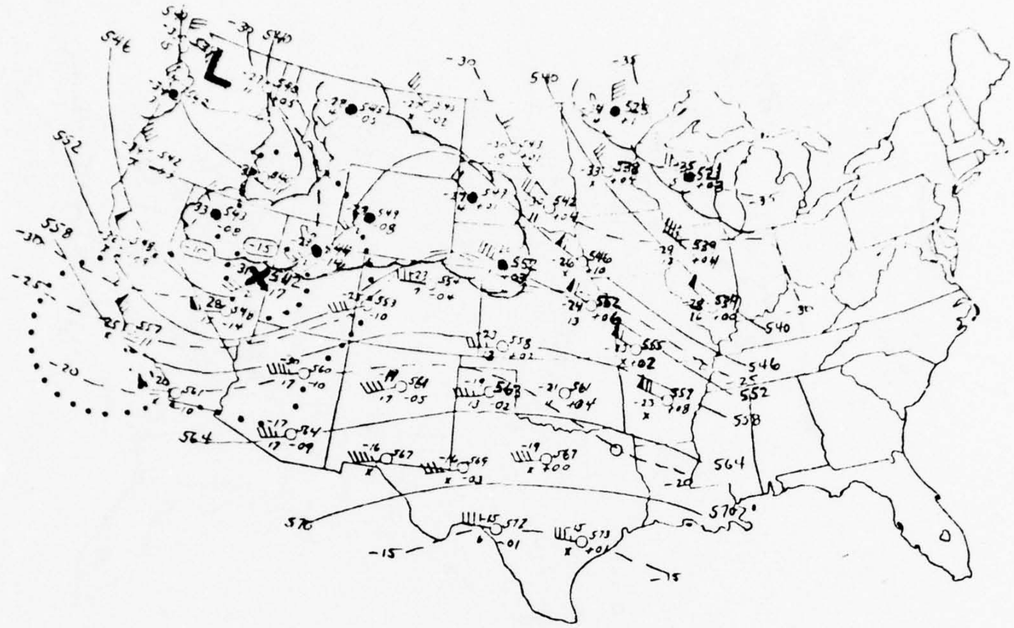


Fig 11. 500mb Analysis, 011200Z March 1977

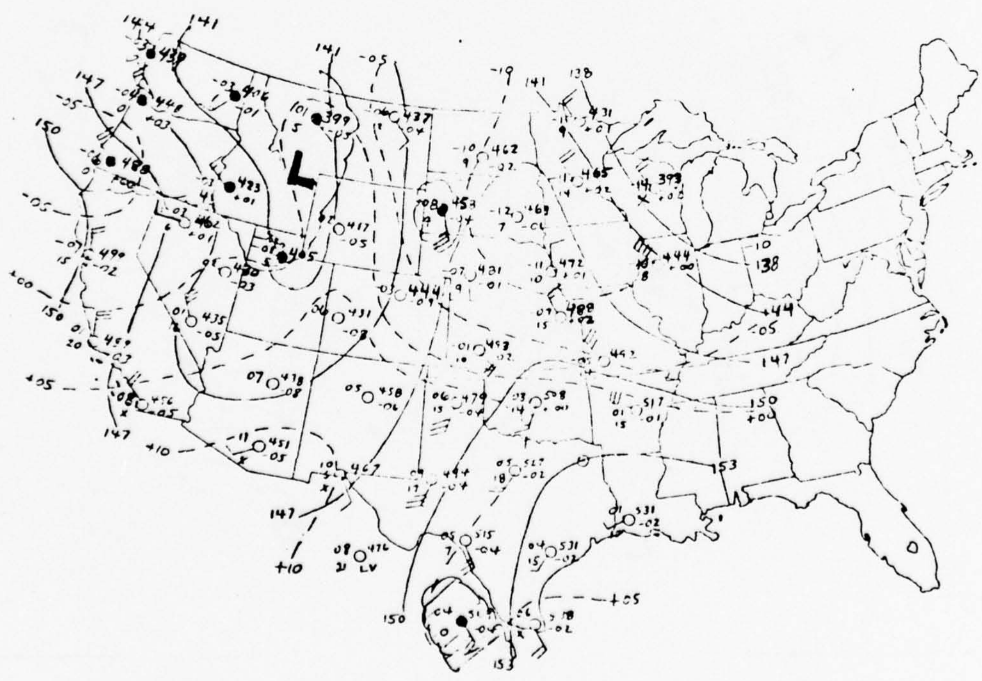


Fig 12. 850mb Analysis, 011200Z March 1977

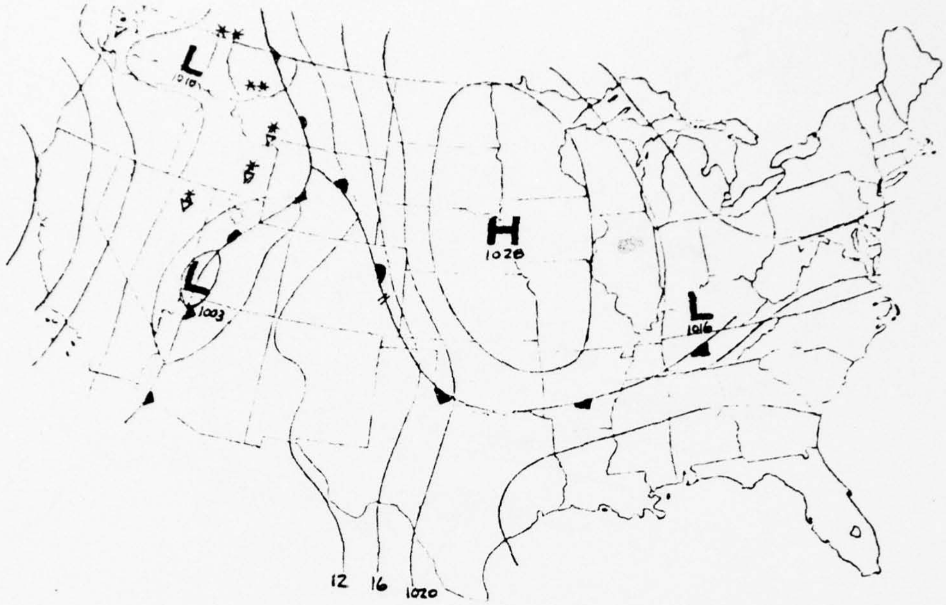



Fig 13. Surface Analysis, 011200Z March 1977

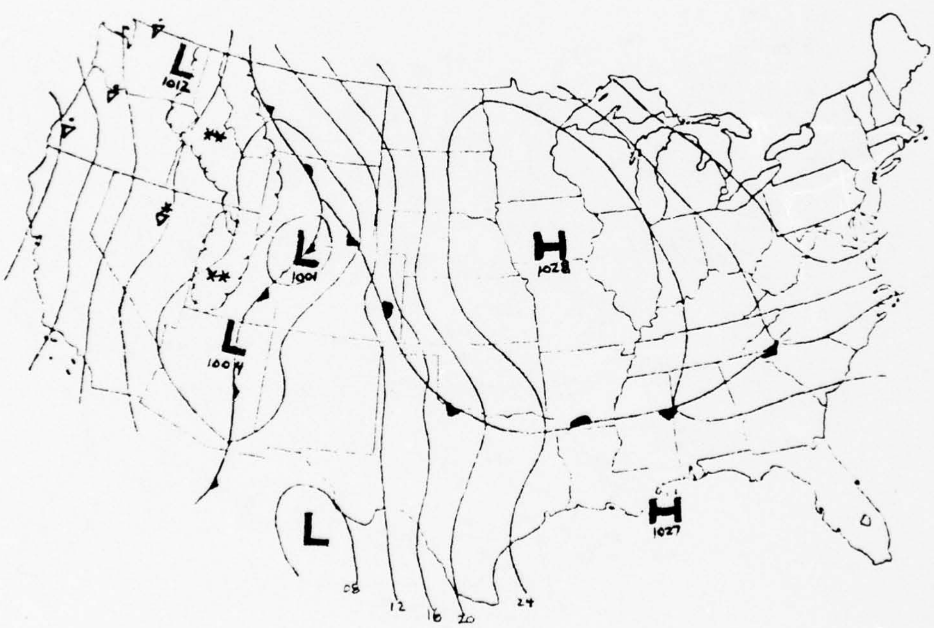
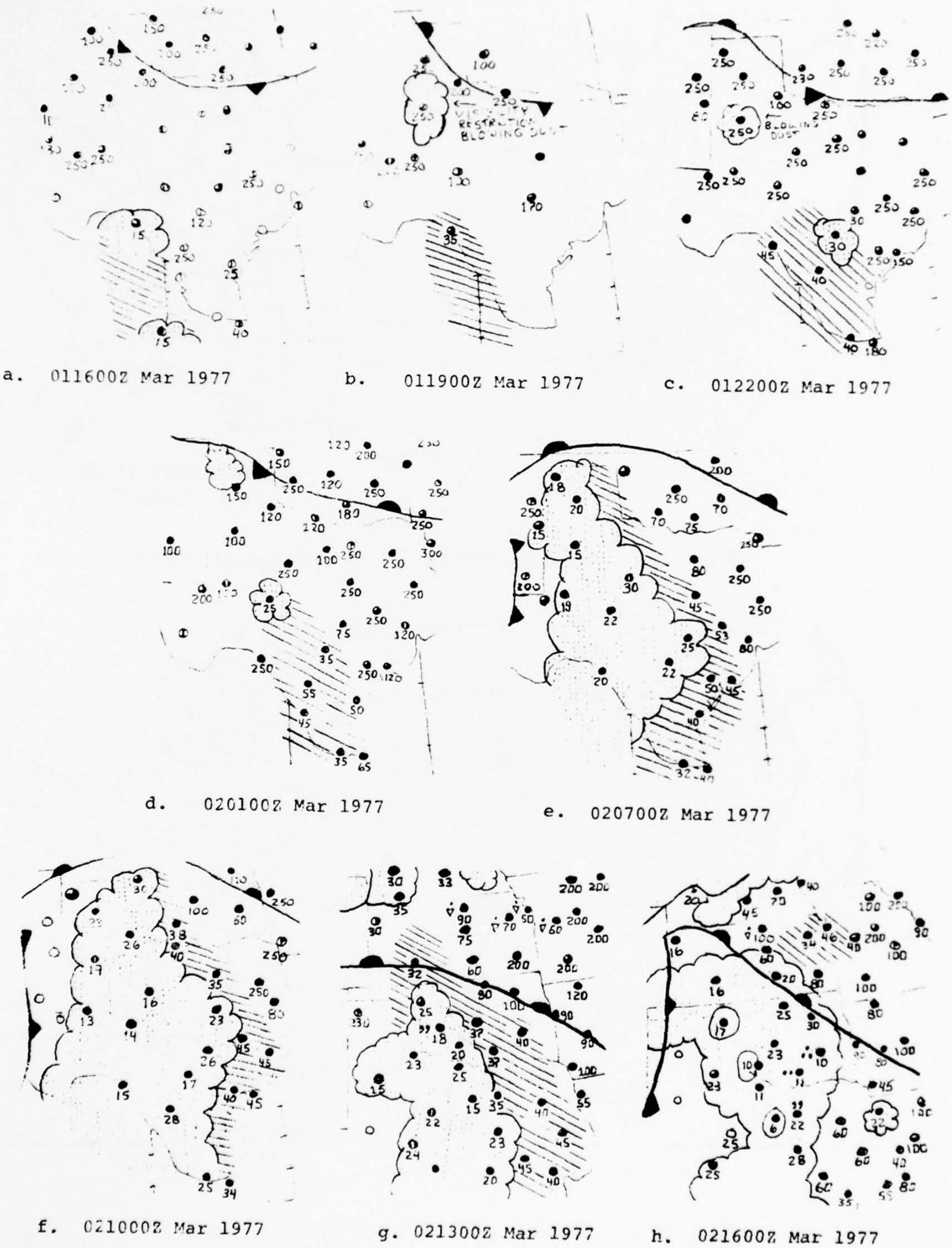



Fig 14. Surface Analysis, 011800Z March 1977



a. 011600Z Mar 1977 b. 011900Z Mar 1977 c. 012200Z Mar 1977

d. 020100Z Mar 1977 e. 020700Z Mar 1977

f. 021000Z Mar 1977 g. 021300Z Mar 1977 h. 021600Z Mar 1977

Fig 15. Weather Depiction Analysis 01-02 March 1977

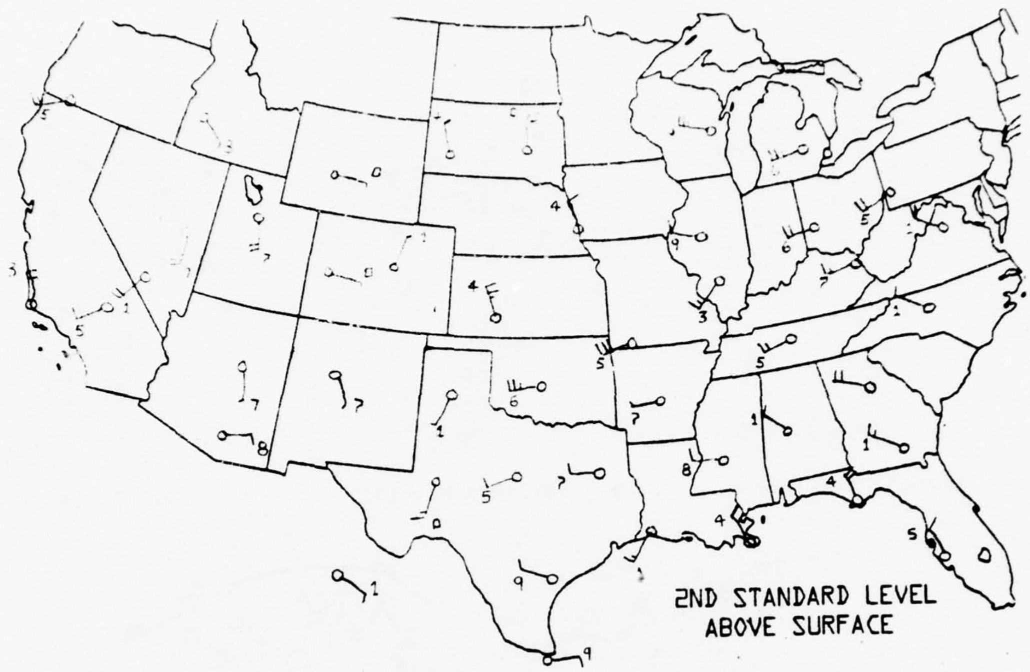



Fig 16. Winds Aloft 010000Z March 1977

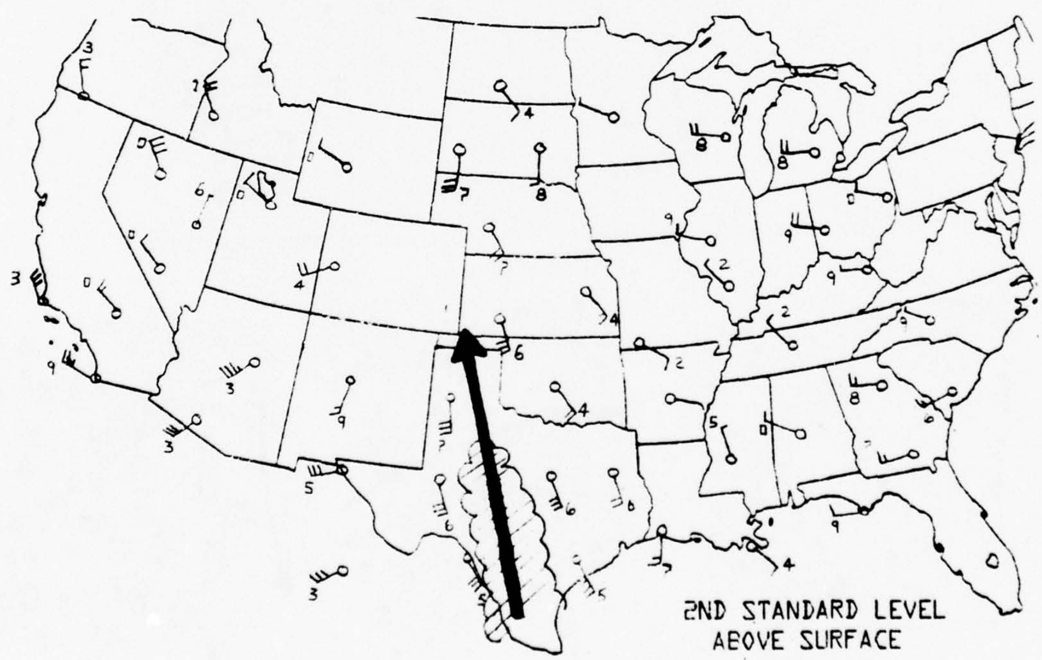



Fig 17. Winds Aloft 020000Z March 1977

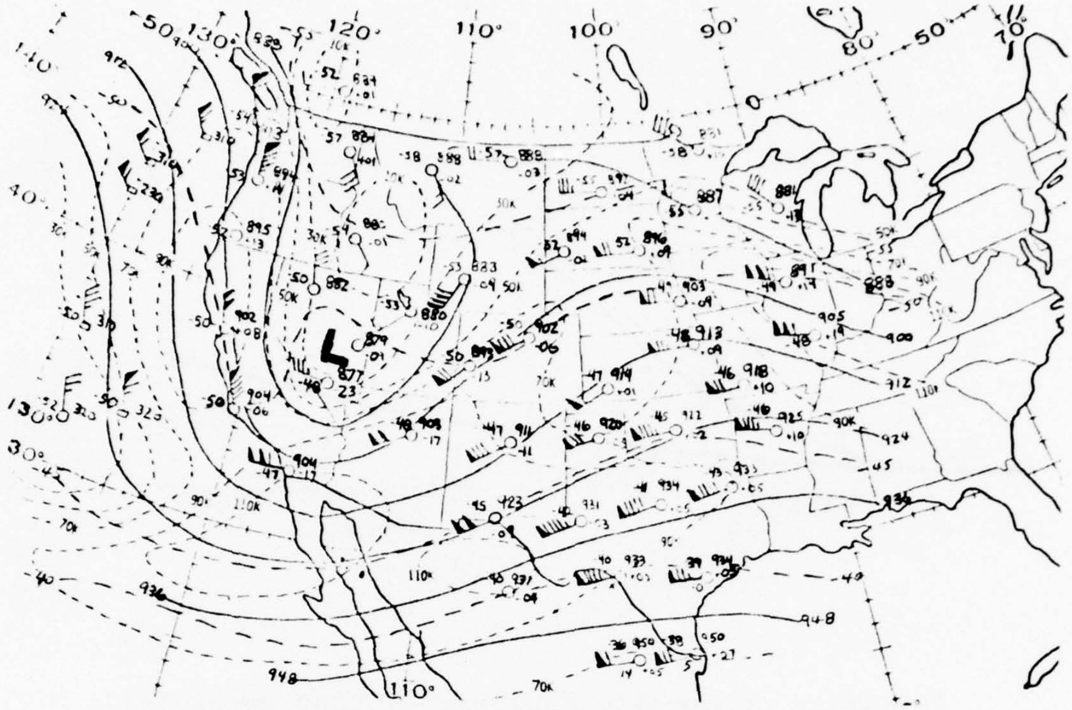


Fig 18. 300mb Analysis 020000Z March 1977

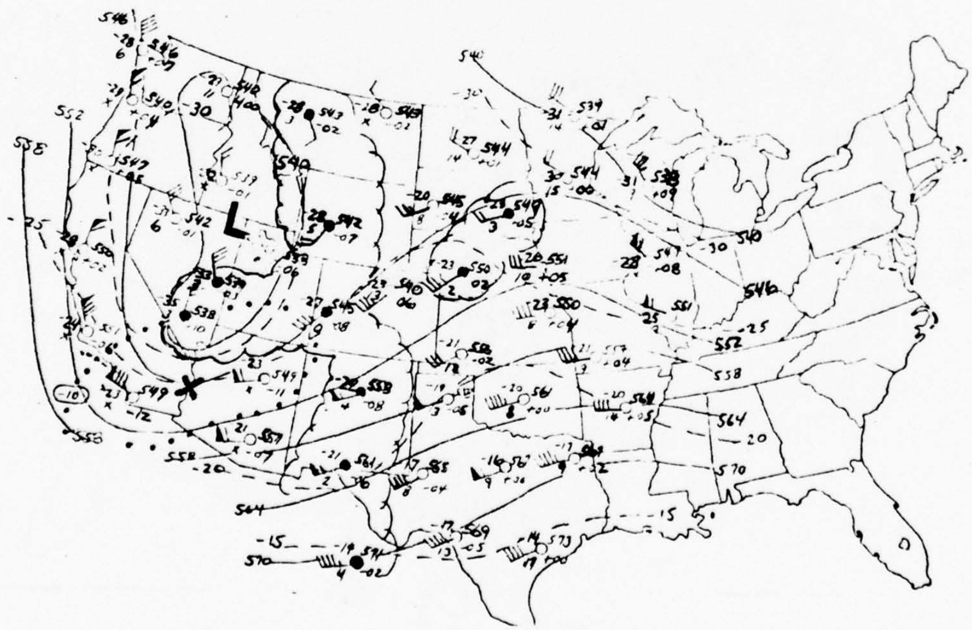


Fig 19. 500mb Analysis 020000Z March 1977

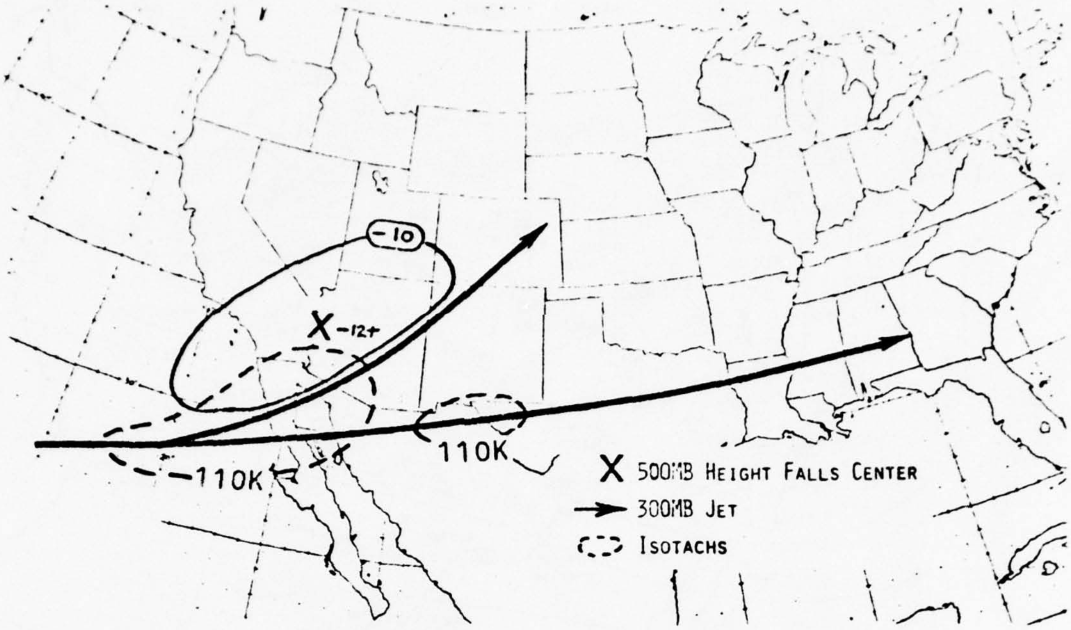



Fig 20. Composite Analysis 020000Z March 1977

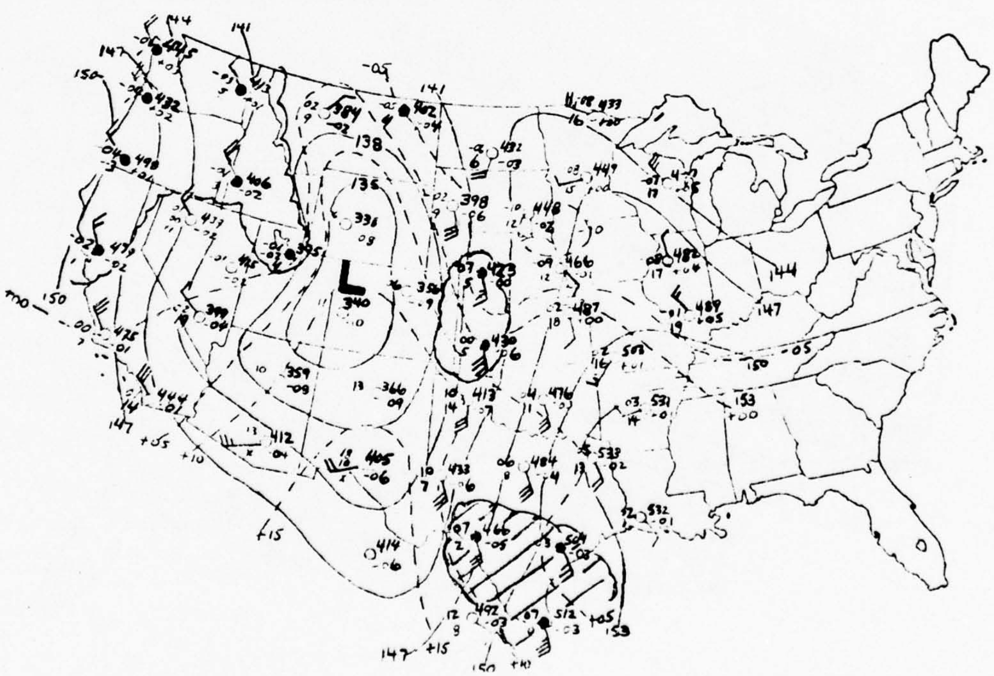


Fig 21. 850mb Analysis 020000Z March 1977

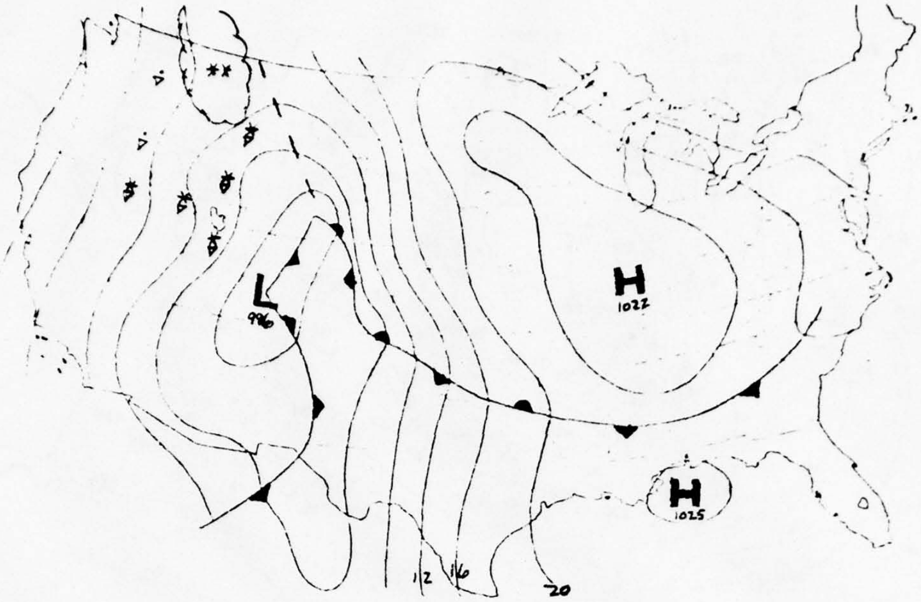



Fig 22. Surface Analysis 020000Z March 1977

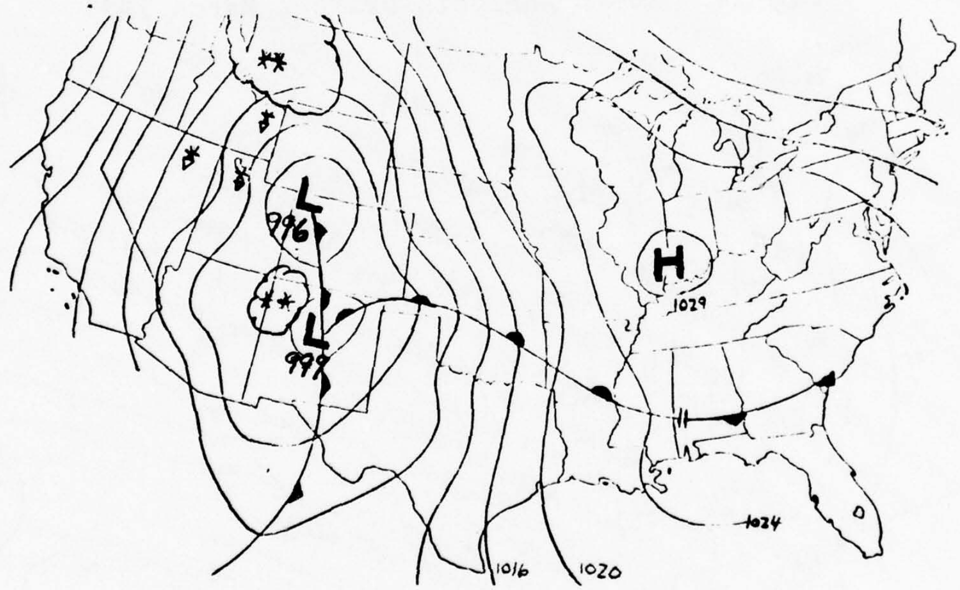



Fig 23. Surface Analysis 020600Z March 1977

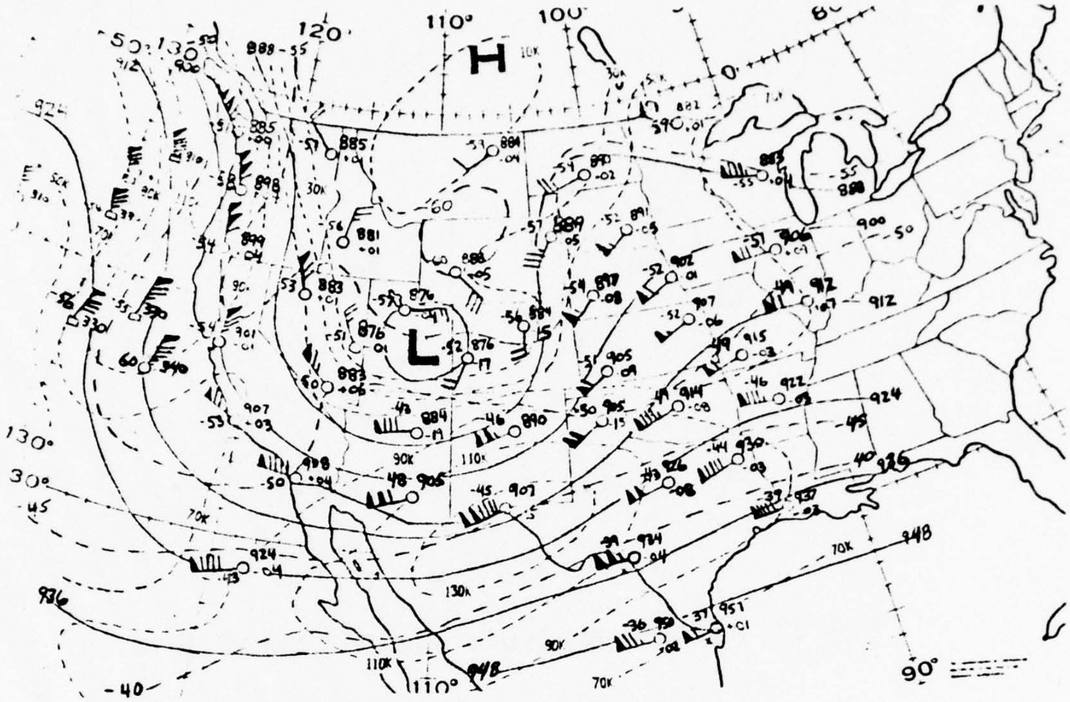


Fig 24. 300mb Analysis 021200Z March 1977

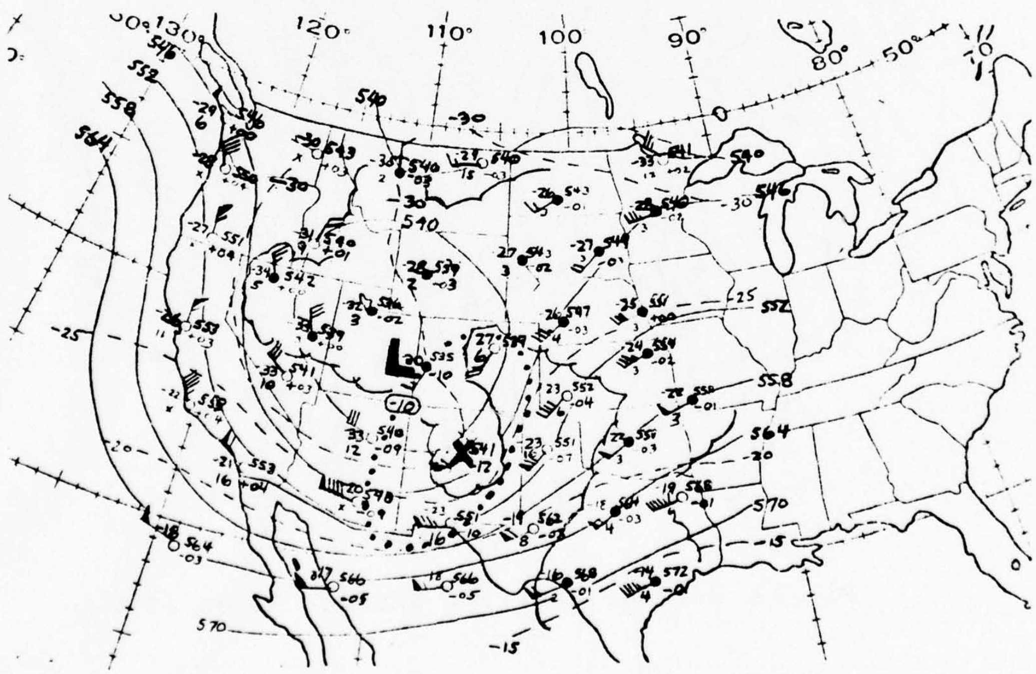


Fig 25. 500mb Analysis 021200Z March 1977

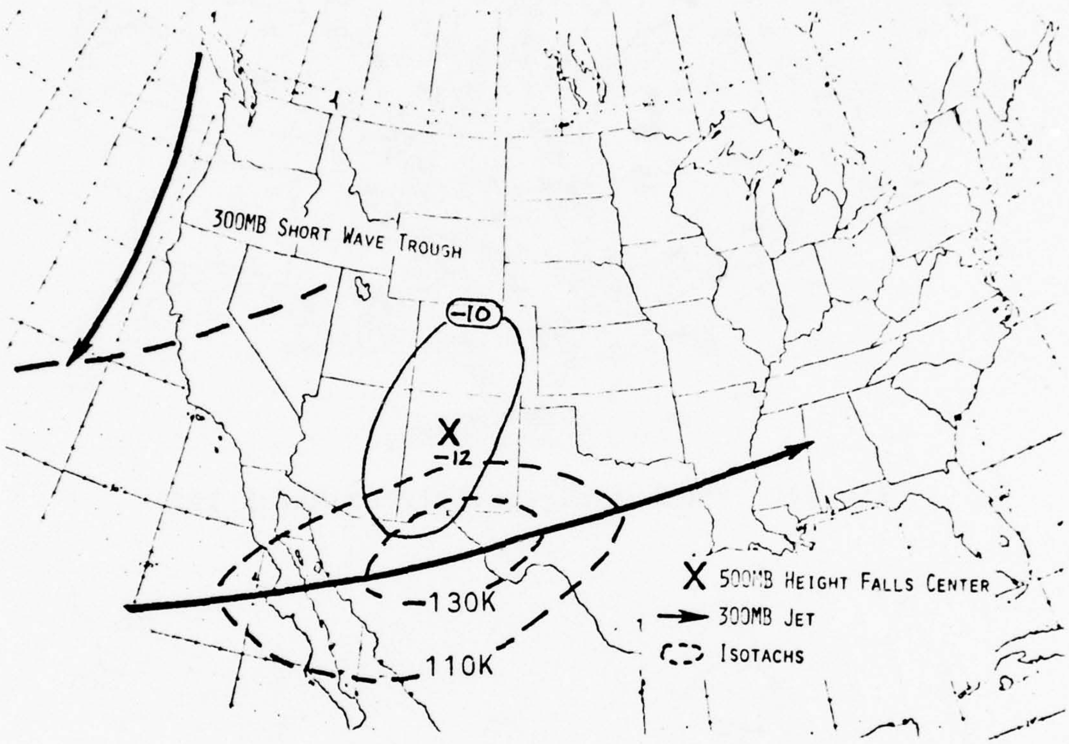



Fig 26.  Composite Analysis 021200Z March 1977

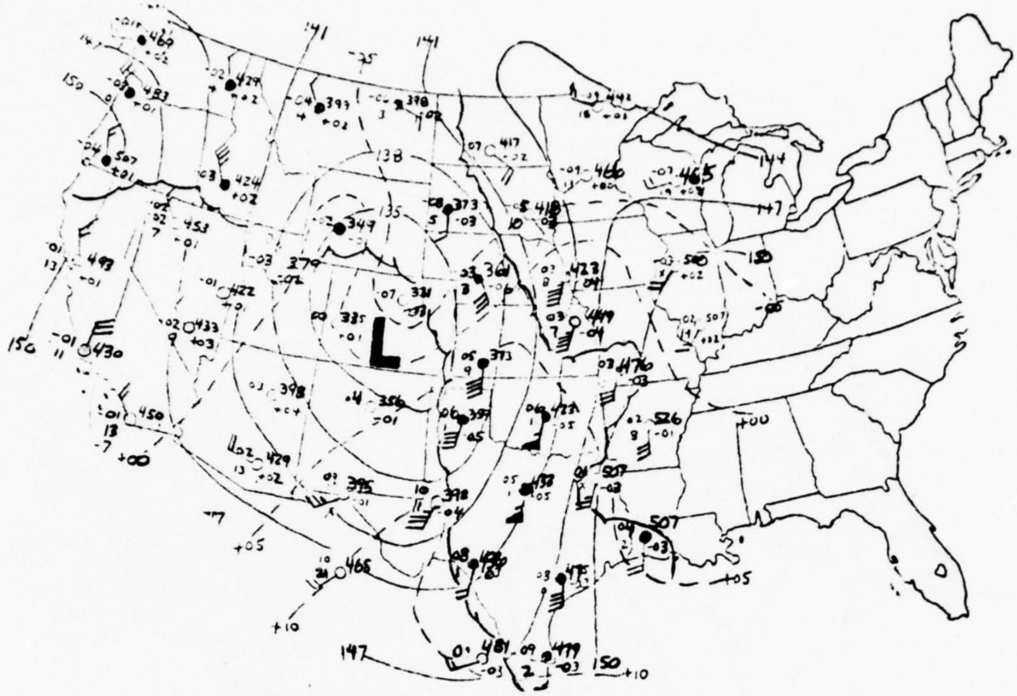


Fig 27. 850mb Analysis 021200Z March 1977

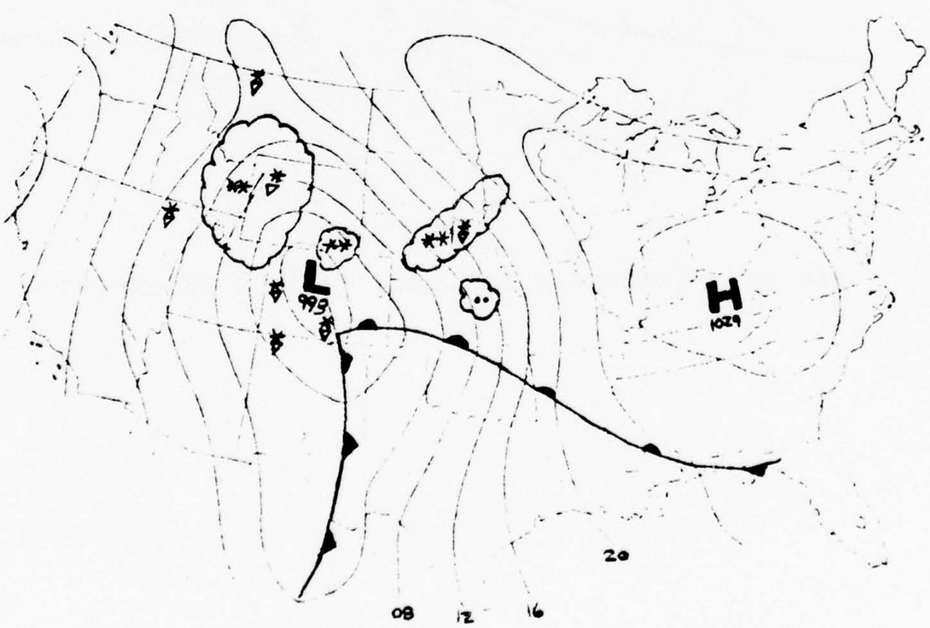



Fig 28. Surface Analysis 021200Z March 1977

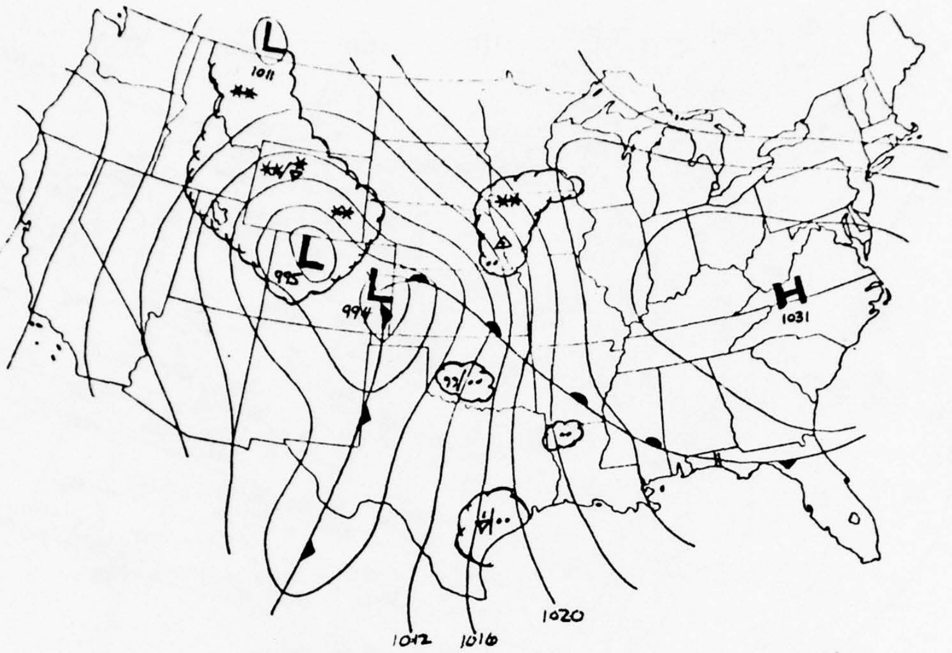



Fig 29. Surface Analysis 021500Z March 1977

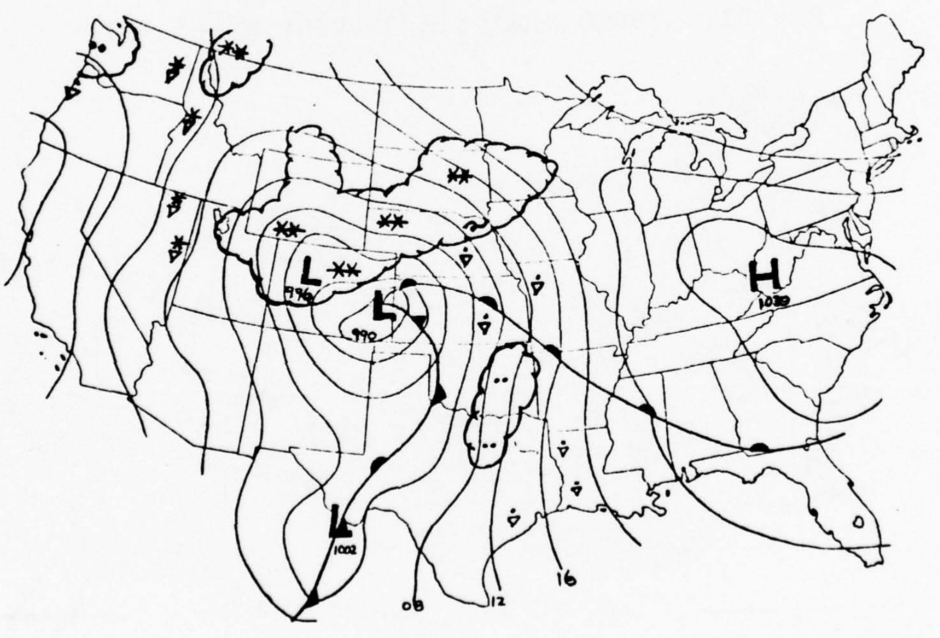



Fig 30. Surface Analysis 021800Z March 1977

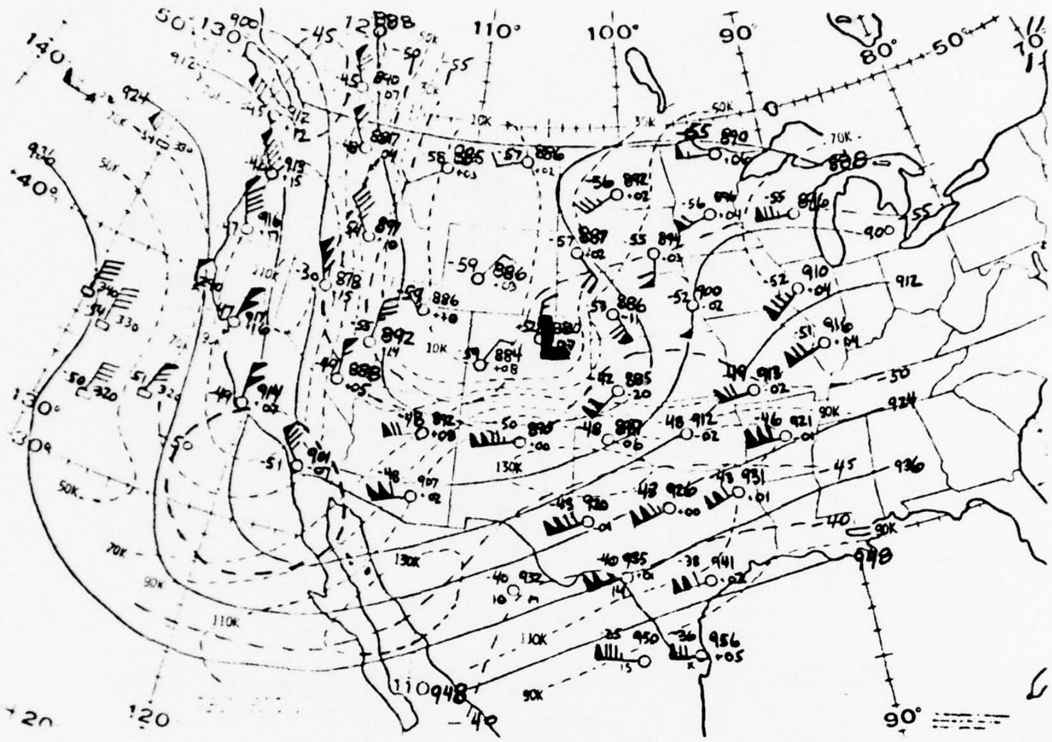


Fig 31. 300mb Analysis 030000Z March 1977

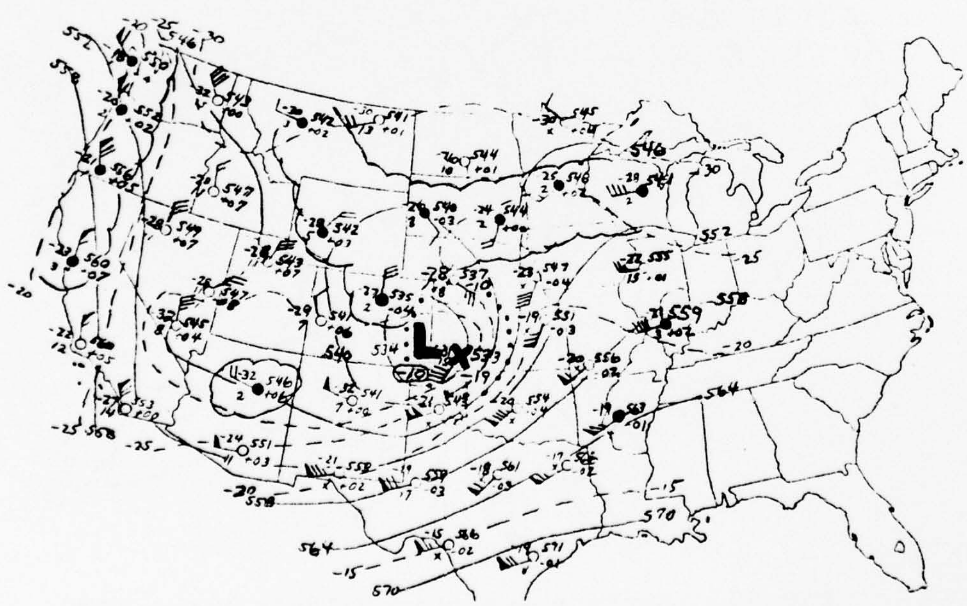


Fig 32. 500mb Analysis 030000Z March 1977

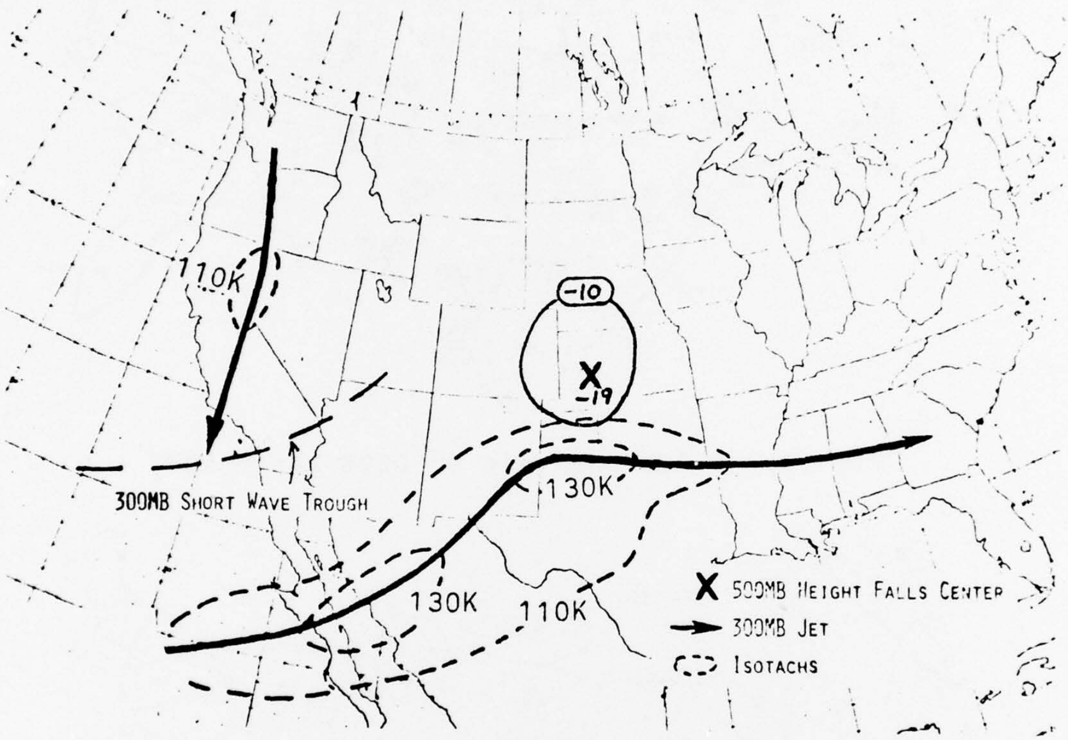



Fig 33. Composite Analysis 030000Z March 1977

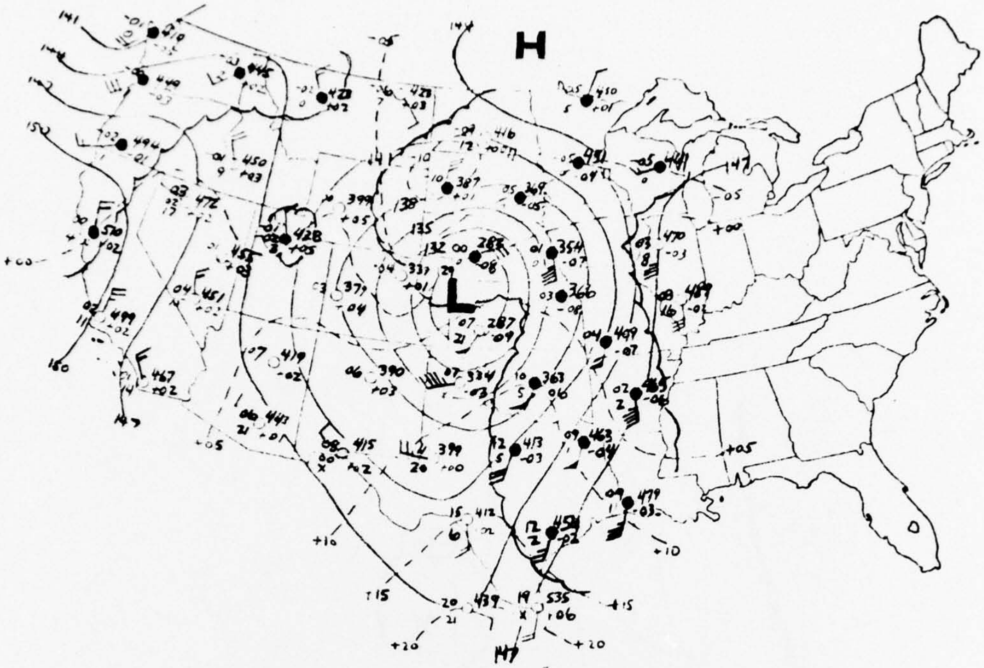


Fig 34.  850mb Analysis 030000Z March 1977

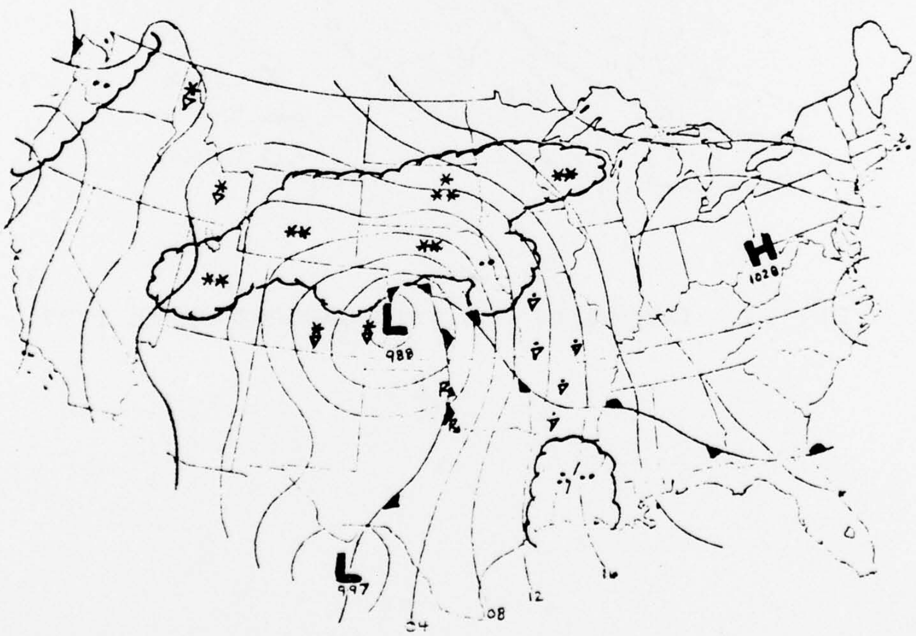


Fig 35.  Surface Analysis 022100Z March 1977

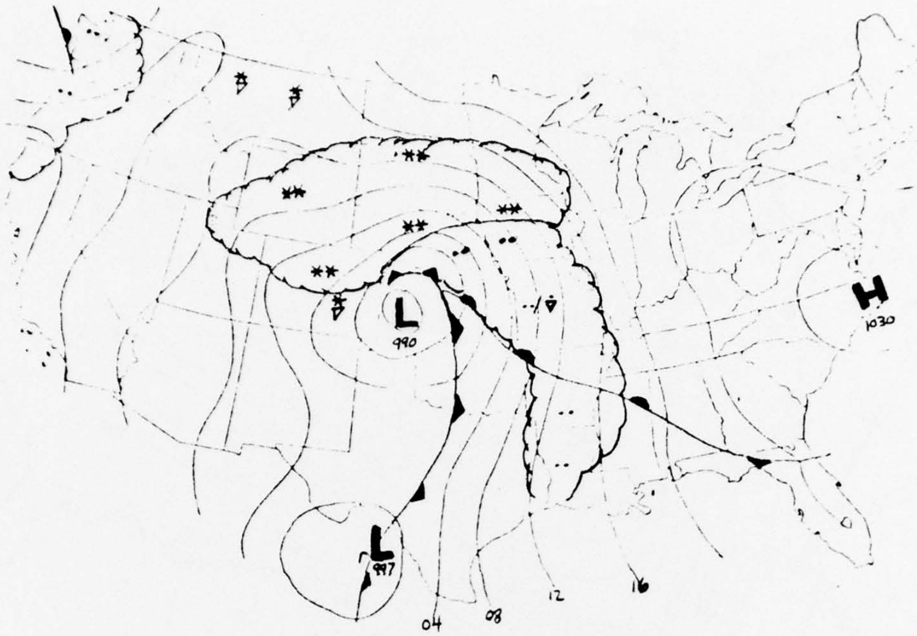



Fig 36. Surface Analysis 030000Z March 1977

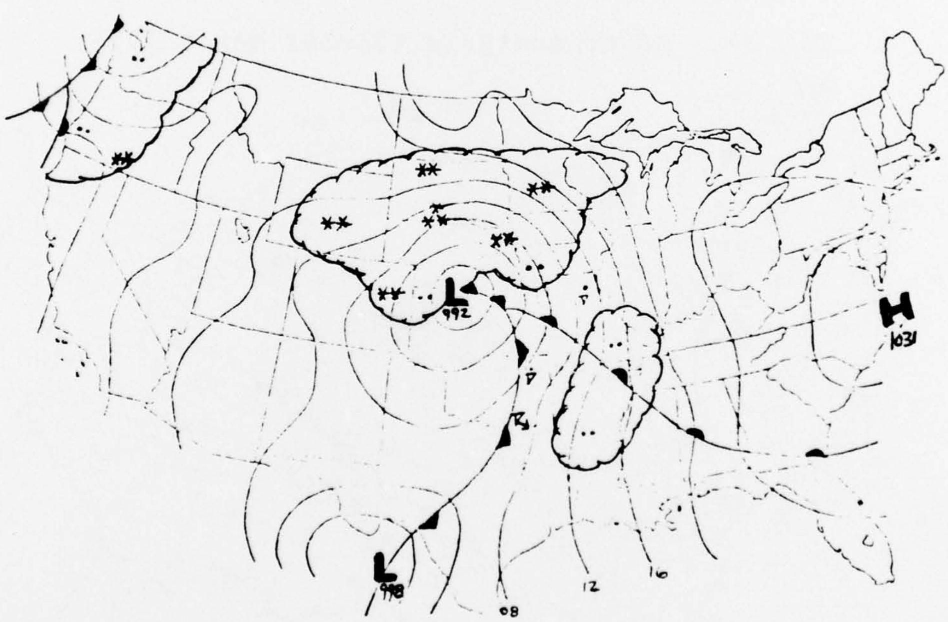



Fig 37. Surface Analysis 030300Z March 1977

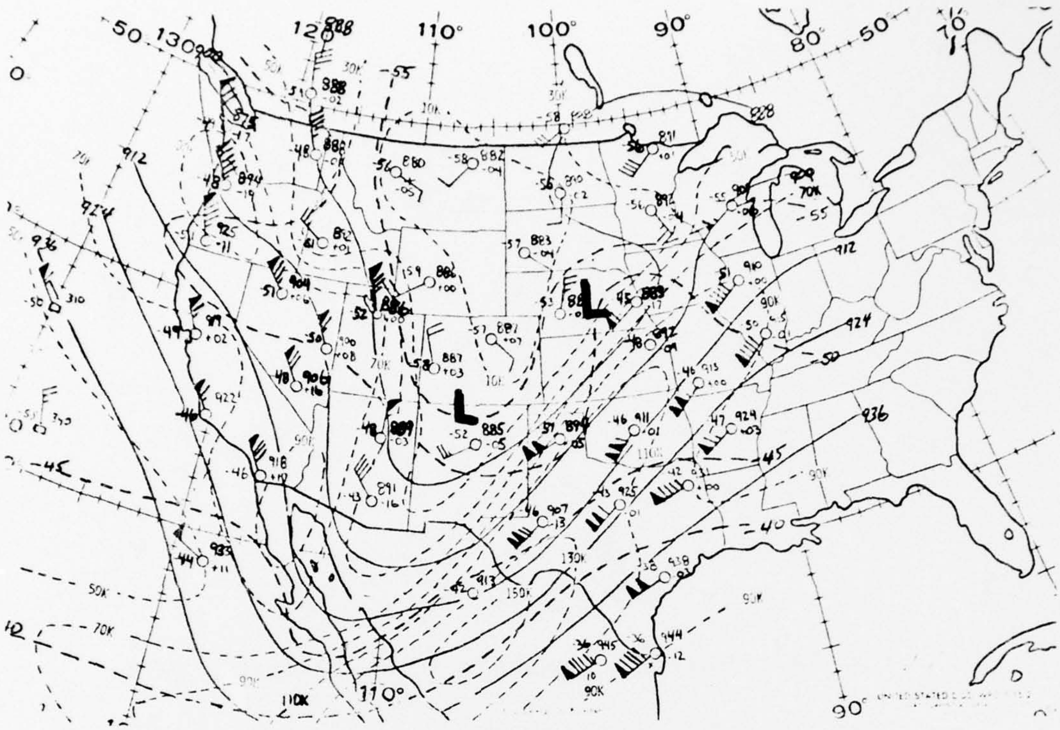


Fig 38. 300mb Analysis 031200Z March 1977

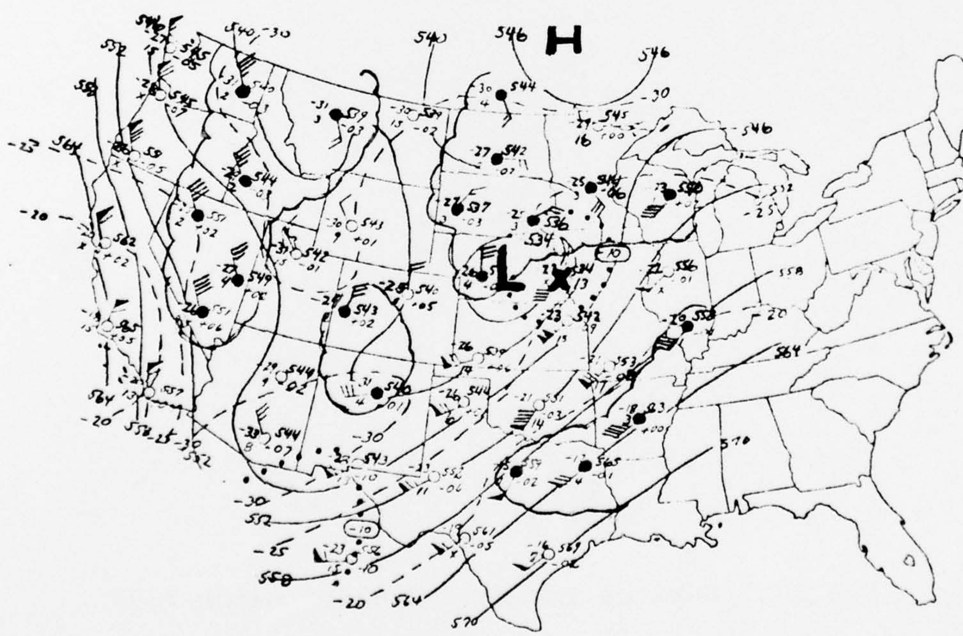


Fig 39. 500mb Analysis 031200Z March 1977

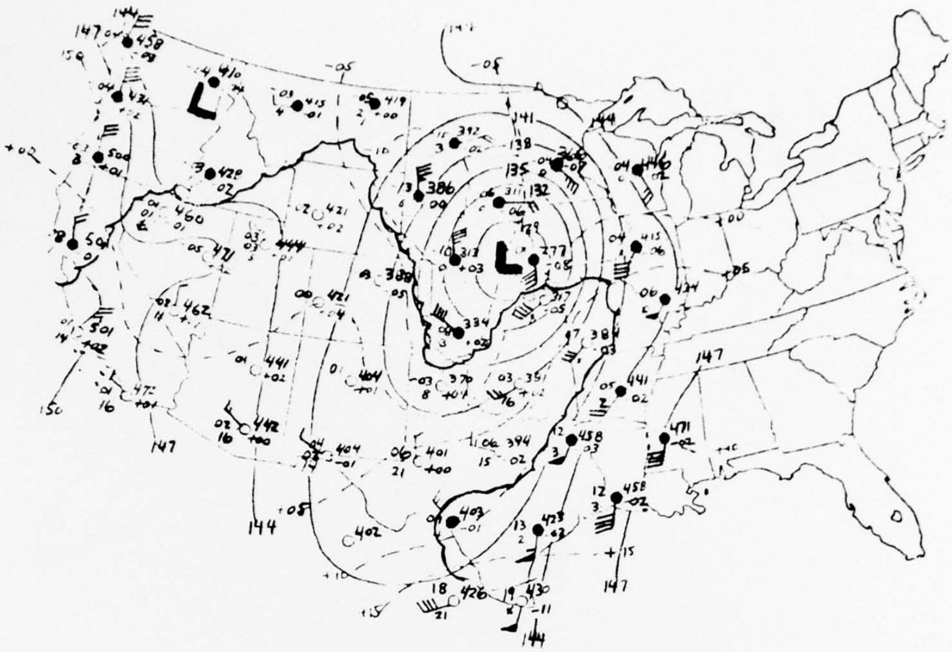


Fig 40. 850mb Analysis 03/1200Z March 1977

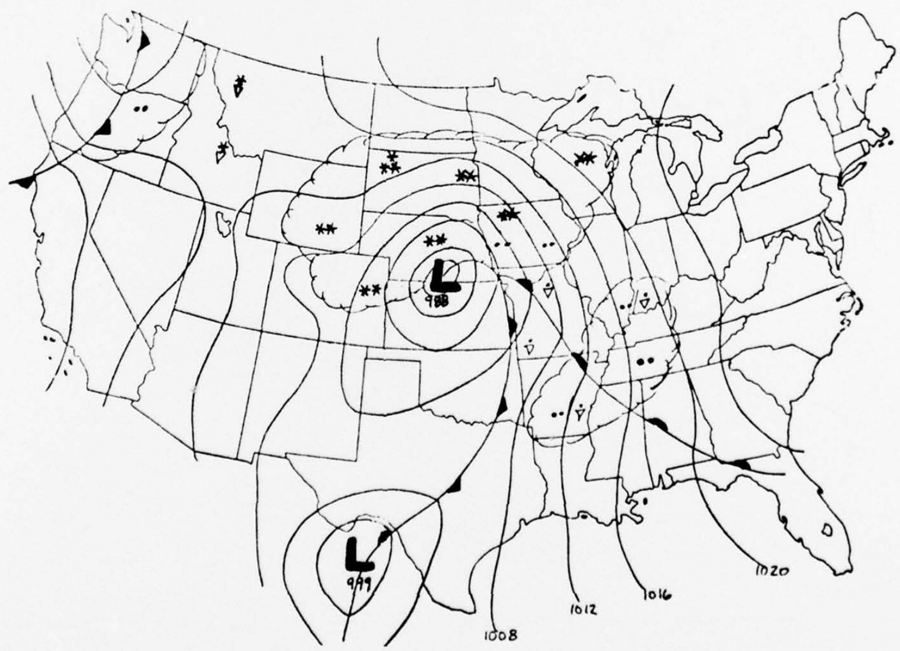



Fig 41. Surface Analysis 030600Z March 1977

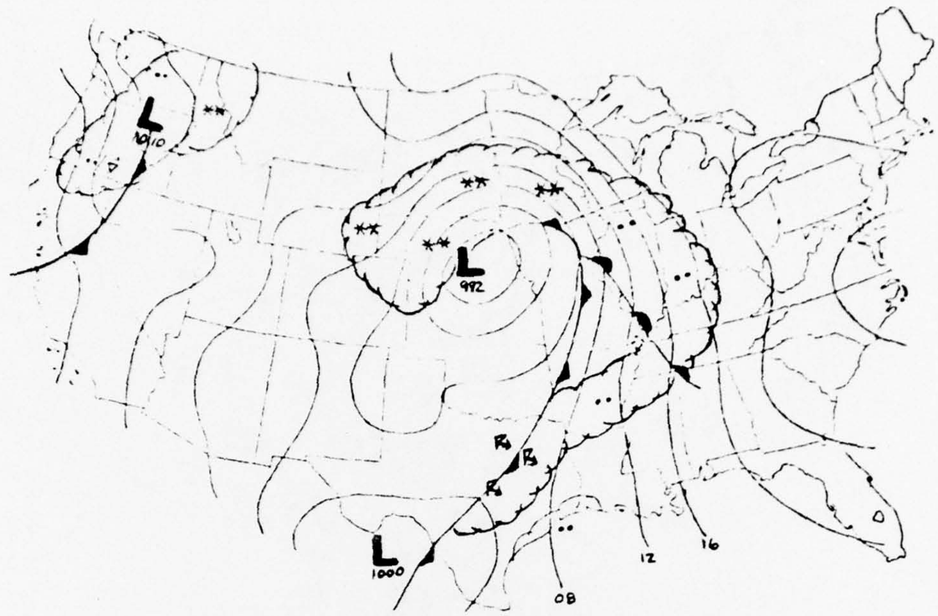



Fig 42. Surface Analysis 030900Z March 1977

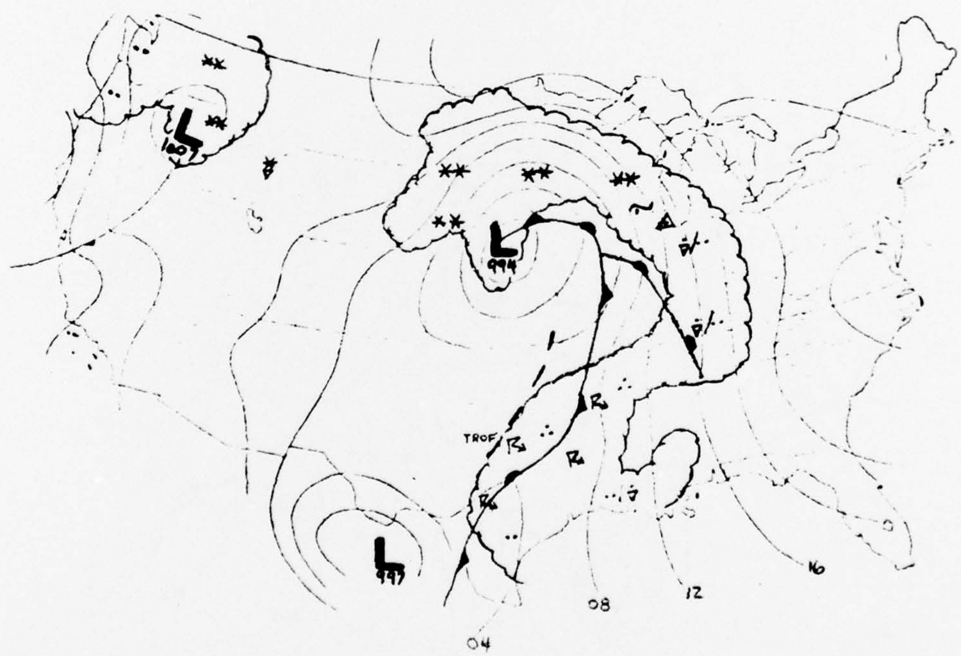



Fig 43. Surface Analysis 031200Z March 1977

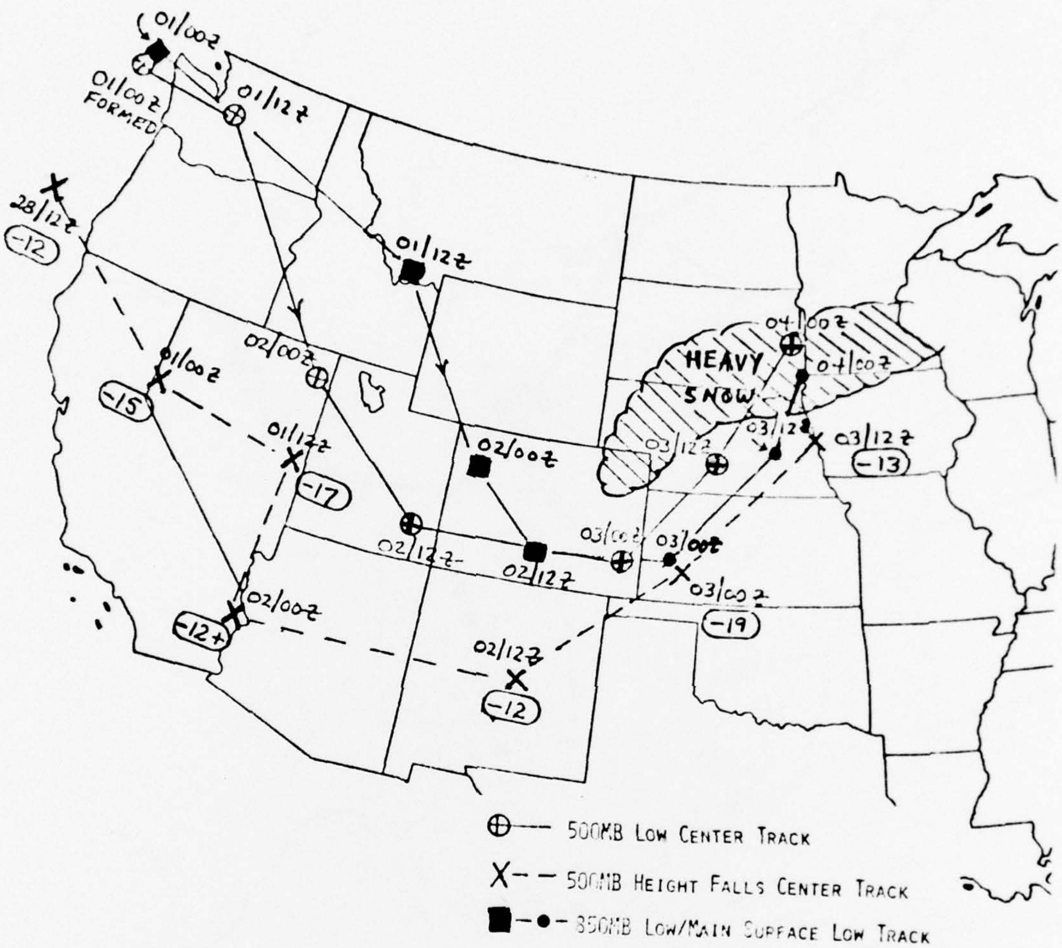



Fig 44. Surface and 500mb low center continuity

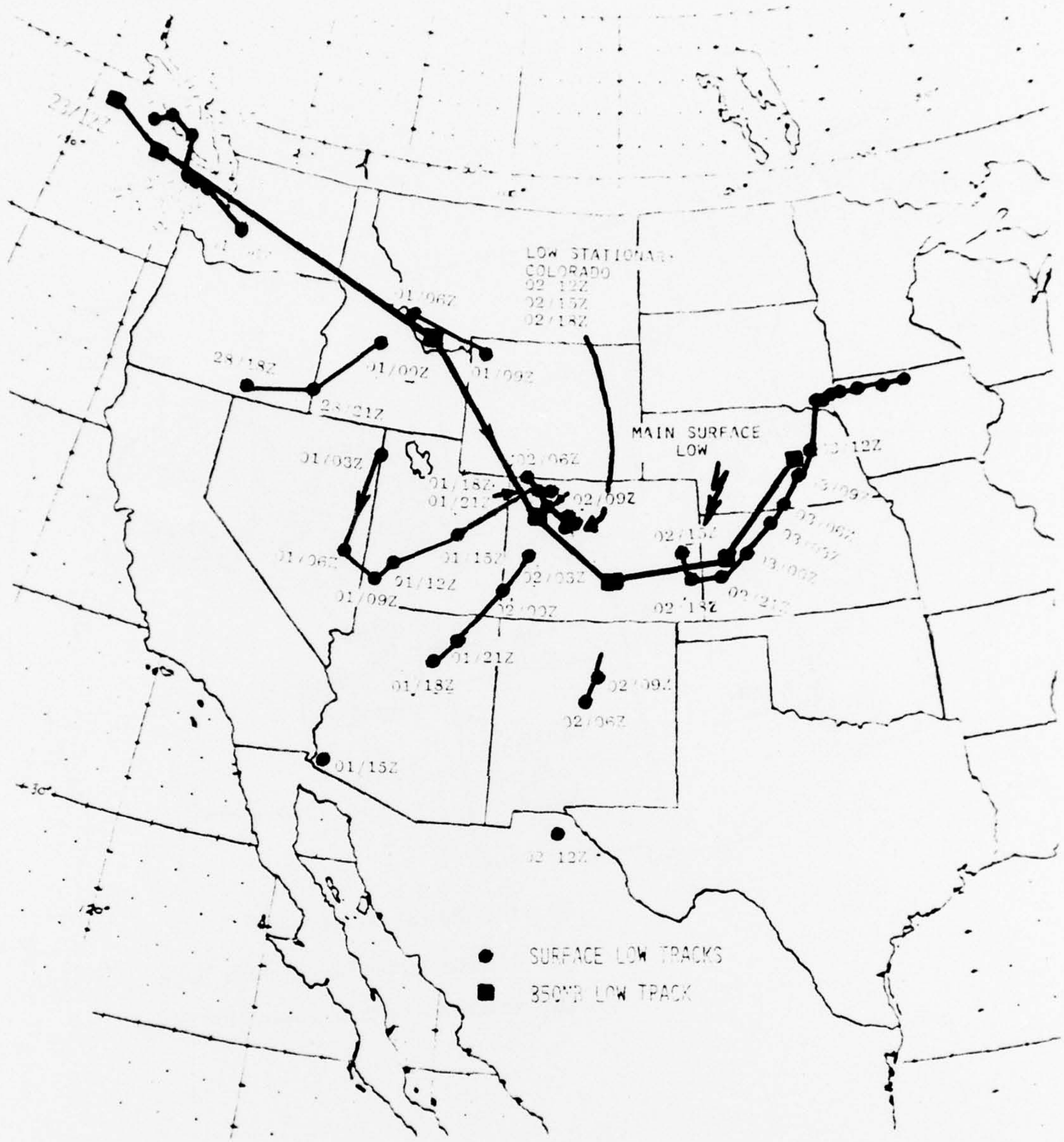



Fig 45. Surface low center continuity

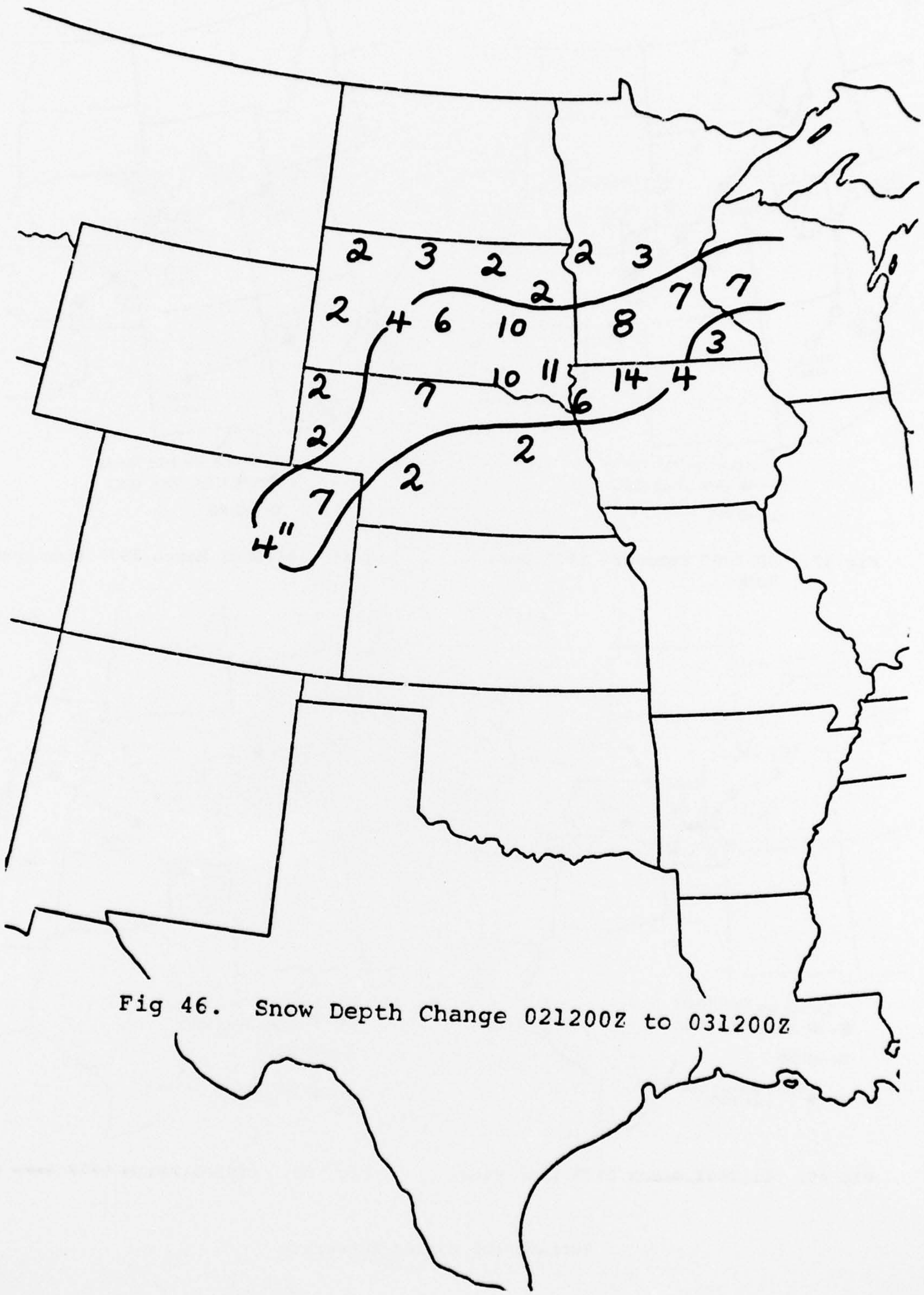



Fig 46. Snow Depth Change 021200Z to 031200Z

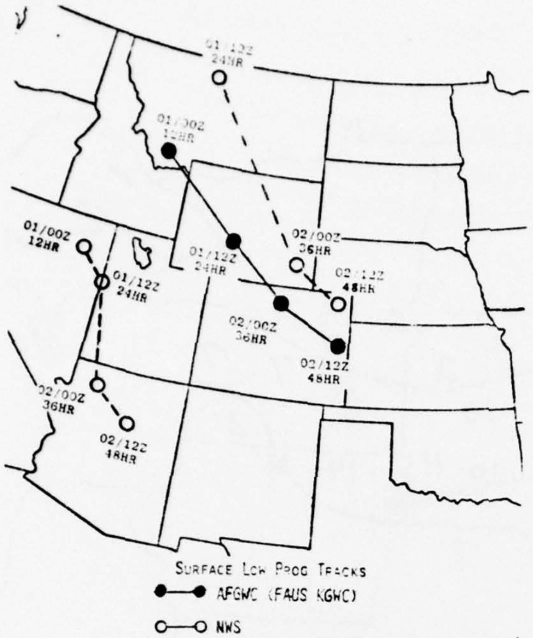



Fig 47. 281200Z February 1977 Data Base

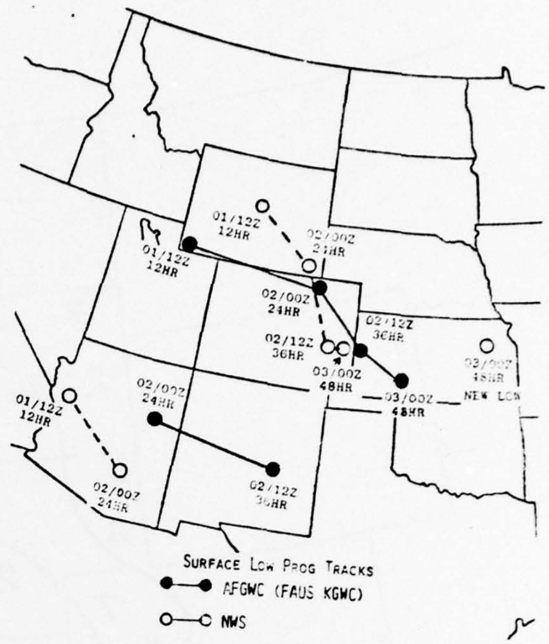



Fig 48. 010000Z March 1977 Data Base

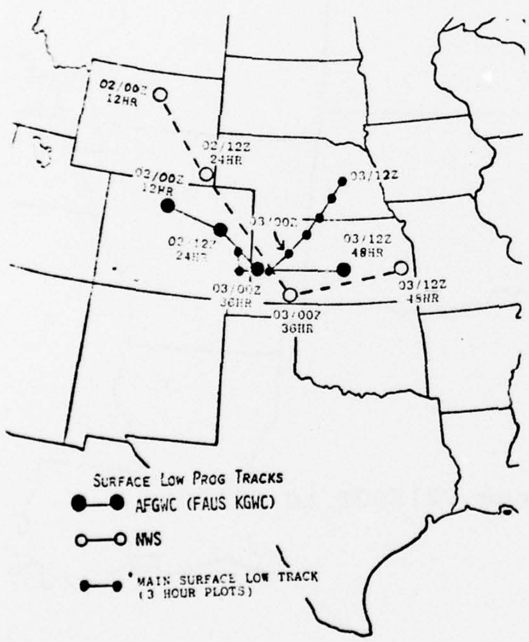



Fig 49. 011200Z March 1977 Data Base

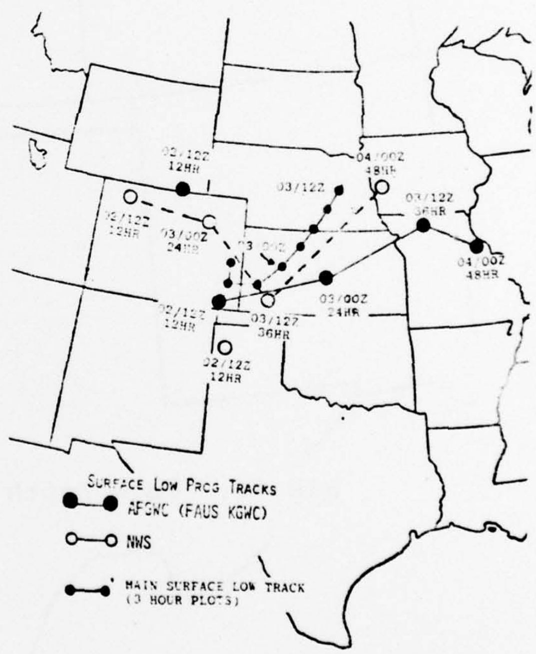



Fig 50. 020000Z March 1977 Data Base

Surface Low Center Forecasts

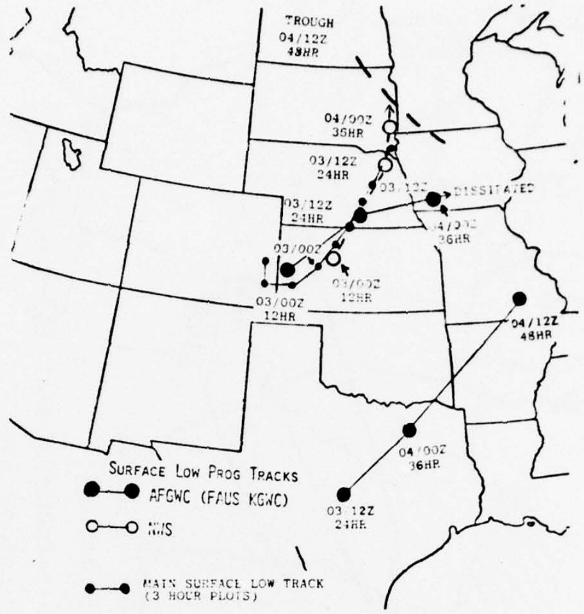



Fig 51. Surface low center forecasts, 021200Z March 1977 data base

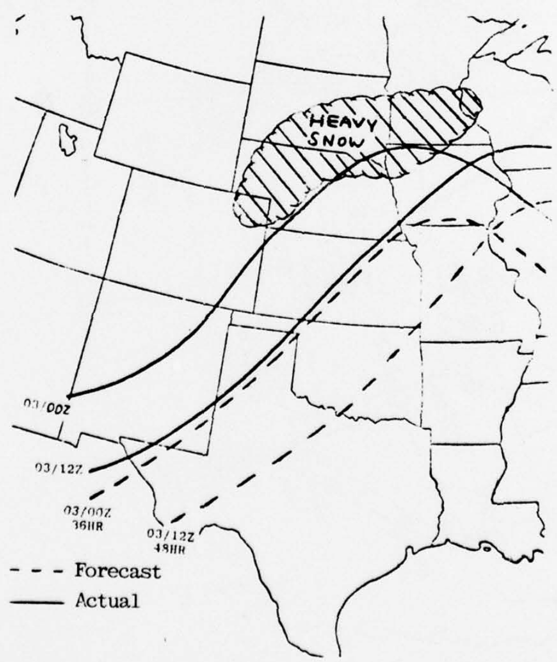



Fig 52. 540 Thickness line forecasts 011200Z March 1977 data base

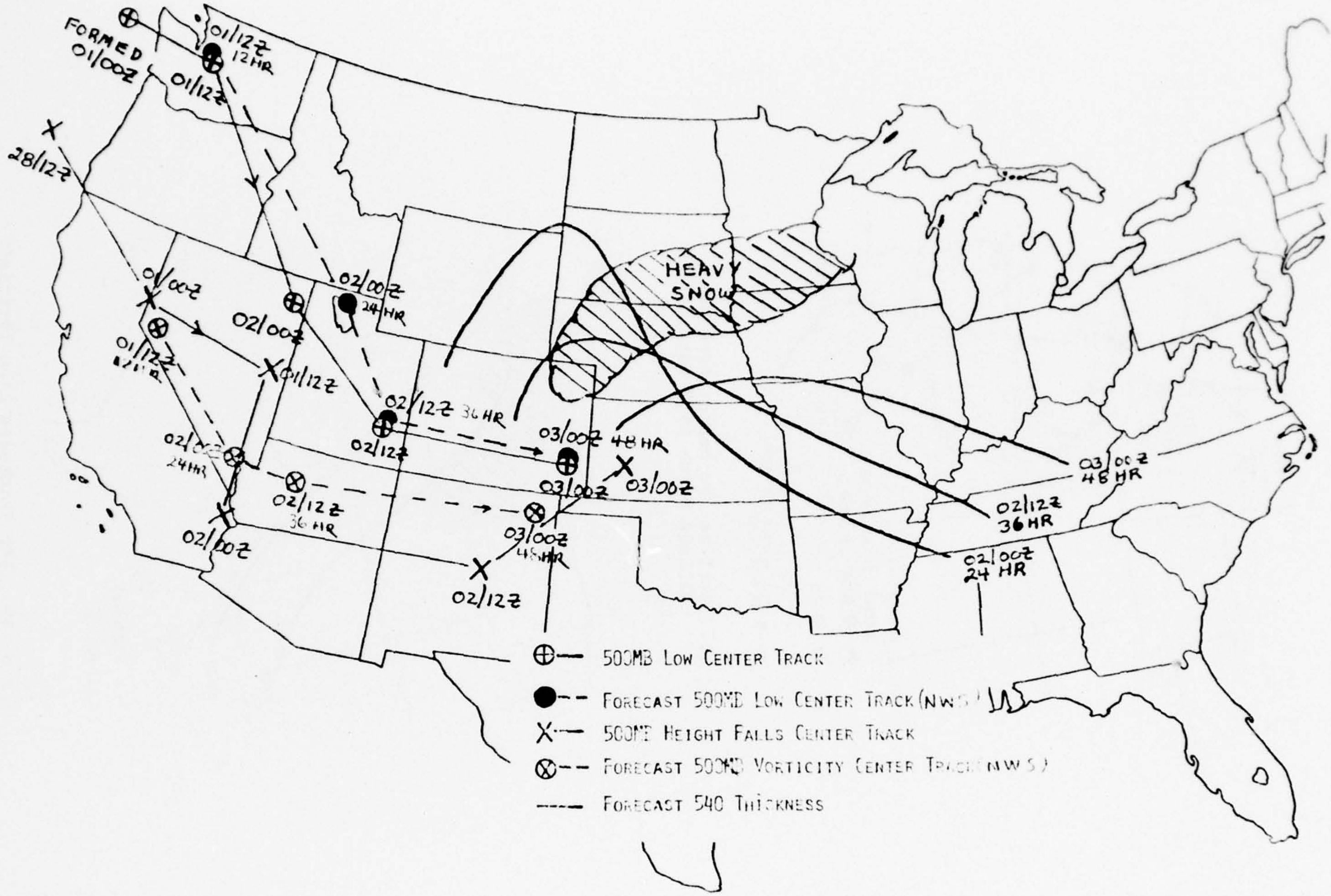



Fig 53. 500mb forecasts, 010000Z data base

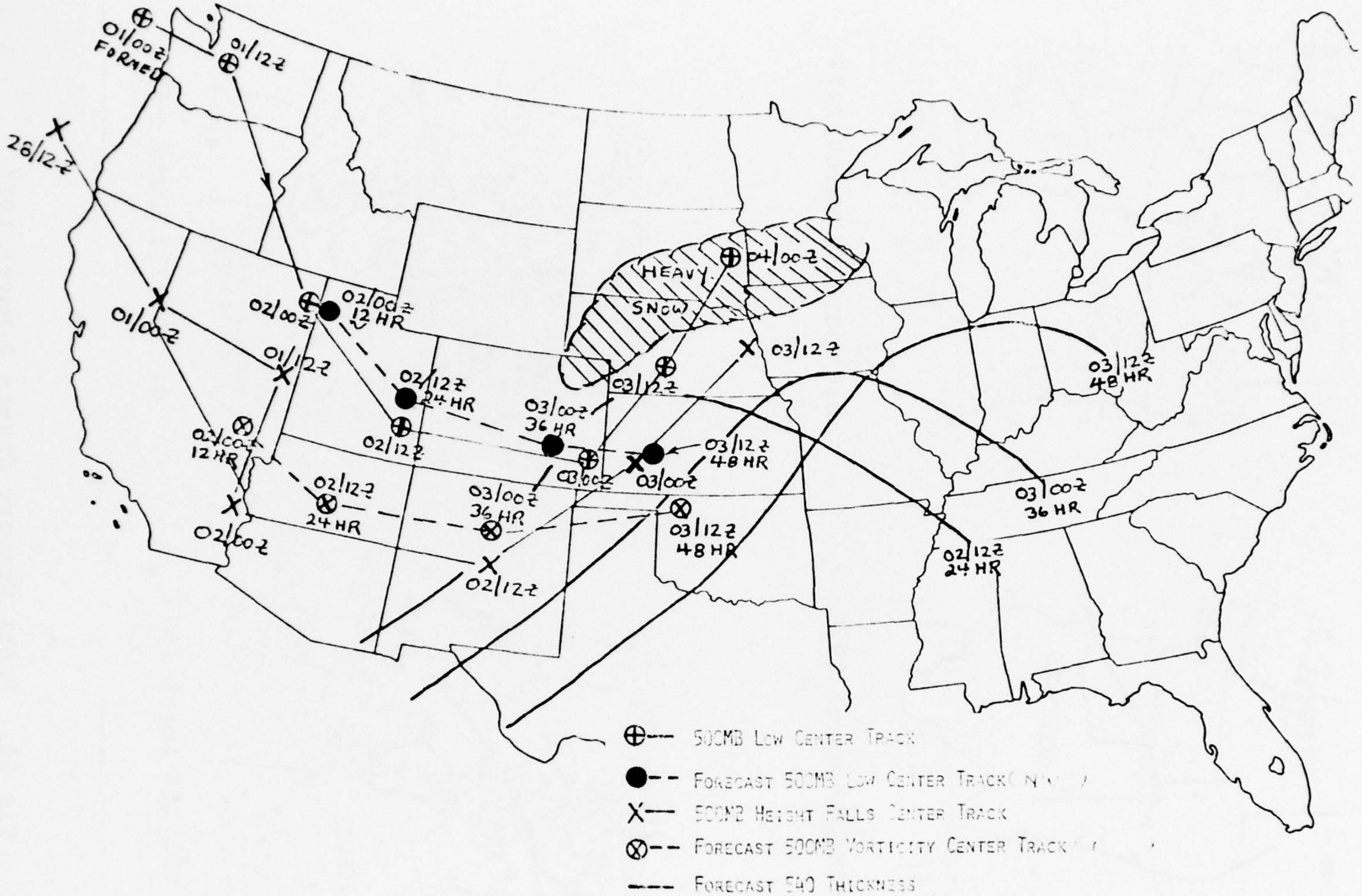
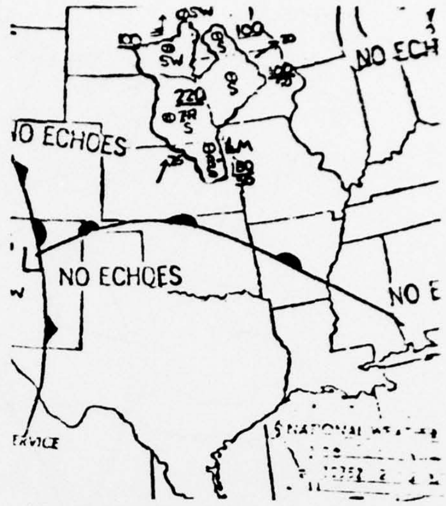


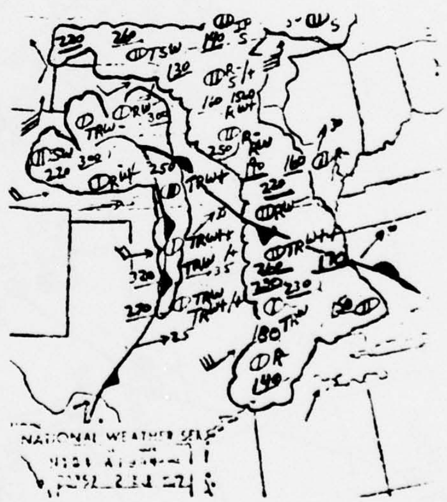

Fig 54. 500mb forecasts, 011200Z data base


a. 020435Z March 1977




b. 021035Z March 1977


c. 021735Z March 1977



d. 022235Z March 1977

Fig 55. Radar Summary Charts 2 March 1977